JETHRO TULL'S

SYSTEM OF

SUCCESSIVE CORN-GROWING

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TILLAGE

A SUBSTITUTE FOR MANURE,

ILLUSTRATED BY THE PRINCIPLES OF

MODERN AGRICULTURAL SCIENCE,

AND THE

PRECEPTS AND PRACTICE

OF

JETHRO TULL.

INCLUDING AN

EPITOME OF TULL'S OPERATIVE DIRECTIONS IN SUCCESSIVE UNMANURED CORN CULTURE,

AND THE PARTICULARS OF

LOIS WEEDON HUSBANDRY,

AND OTHER INSTANCES OF

TULL'S METHOD OF FARMING.

BY

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"No canon having limited what we shall think in agriculture, nor condemned any of its tenets for heresy, every man is therein a Free-thinker, and must think according to the dictates of his own reason, whether he will or no. And such freedom is given, now-a-days, in speculations in natural philosophy, that it is common to see people, even in print, maintain that there are Antipodes; that the earth moves round the sun, and that he doth not set in the sea, without being censured for these and many other formerly heterodox opinions; and any one may now, upon solid arguments, contradict Aristotle himself publicly any where, except in the schools."—Tull.

TO THE

RIGHT HON. WILLIAM EWART GLADSTONE,

M.P. FOR THE UNIVERSITY OF OXFORD.

SIR,

The kindness you have so greatly vouchsafed to myself will, I trust, induce you to give an indulgent reception to the following little volume, which, from motives of gratitude, I now most respectfully dedicate to you.

I have the honour to remain,

SIR,

Your ever obliged, and most humble Servant,

A. BURNETT.

DEE BANK, May, 1859.

PREFACE.

THERE is perhaps no circumstance in modern husbandry better ascertained, or which, as an experiment, has attracted greater agricultural interest, than the fact that on a single acre of good clay land, valued at £2 of rent, including tithe, the Rev. Samuel Smith, of Lois Weedon, Northamptonshire, has grown twelve successive crops of wheat without the application to the soil of any manure whatsoever. What, however, gives importance to the experiment is that neither *degeneration of quantity* nor *dimunition of quality*, in the yearly produce, have exhibited themselves in this long period, but, on the contrary, an acreable yearly average of thirty-four bushels of marketable corn, at an average annual expense of about £6, (including rent, and every other out-going up to, and including marketing,) has sustainedly been harvested, affording this simple but significant calculation :—

Thirty bushels of wheat, at the tithe acreage of 7s per bushel	£11	18	0
Rent, tithe, and expenses	6	0	4½
Yearly profit per acre, besides the value of the straw.....	5	17	7½

Other experiments similarly conducted, and hitherto attended with like success, are on trial in various parts of the country.

In perusing the records of English Agricultural Polity backwards, instances identically the same in principle as the foregoing, and not less relatively remunerative, are, from time to time, to be met with, till at last the enquiry terminates in the case of JETHRO TULL, the inventor of the system, who, before his death in 1741, had grown thirteen unmanured crops of corn, without intermission, and without decrease, in one and the same ground; and in the latter years of his practice, tilled in the same method, no less than 120 acres of wheat of a season,—with this immense practical superiority over the majority of the amateur experiments of the present day, namely, the use of the plough for inverting the soil, and not of the spade or fork, as in them.

In no aspect of the grain market, and most assuredly not in its present one, can it ever be irrelevant to inquire whether Tullian Corn Culture would, or would not be more profitable than a continuance in the present method of Cereal Husbandry; and, accordingly, the design of the following little work is,—1st, to relate the history, from Tull's time upwards, of this unmanured and unintermittent mode of Corn Husbandry; 2ndly, to explain the entire accordance of that mode with the physical laws of culture; and, 3rdly, to set forth in methodized and concentrated form

Tull's own directions for its operative performance. This done, the practical man is left to draw his own conclusions, whether the facts and principles involved in the narrative do not point to the expediency of a considerable measure of reform in the present routine management of the Tillage Farm.

Thus, for instance, if, as many leading agriculturists affirm, (and to whose opinions the author himself is disposed to assent,) Grazing Husbandry must be more resorted to in the corn districts than it now is, the reader has in the following chapters presented to him what there is of evidence to shew, that Corn can profitably be grown without the stimulus of manure; and, hence, that the manurial products of the Homestead may be exclusively and more advantageously distributed on the permanent grass fields.

Again, if, as numerous other agricultural authorities argue, the change (for probably there are few reflecting men who do not discern signs of near approaching change of some kind) must consist in increasing the breadth of cereal culture, in room of lessened cattle crop growing, it is fit that those of that way of thinking should be enabled, from the actual history and facts of Tullian Husbandry,—now, for the first time, systematically related—to determine whether the heavy outlay of capital, the great annual expense, and, too frequently, the actual loss involved in the manufacture of manure by means

of live stock, especially on soils unfitted to the folding of sheep on the root field, are not wholly, or to a large extent, avoidable evils in the management of Corn Farming.

In the introductory chapter ample testimony will be found to prove that, anterior to the engrafting of fallow cattle crops on the husbandry of England, *pure* cereal tillage prospered abundantly under circumstances infinitely less favourable to its success than those of the present day.

POSTSCRIPT.

It may here be mentioned, that those articles proposed in the Prospectus of the work to be inserted in the Appendix, but now omitted, have been embodied, in other forms, in the text, which has also been otherwise considerably extended.

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APPENDIX.

TILLAGE A SUBSTITUTE FOR MANURE.

CHAPTER I.—INTRODUCTORY.

It is undeniable that coincident with the introduction and spread of Root Culture, English Tillage Husbandry has immensely advanced in improvement. Nevertheless it is now no heresy to say, that, from the many changes in agricultural resources and relations within the last twenty years, the specific advantages of Rooting are materially neutralized; while, moreover, many grave objections, to which it has ever been amenable, are gradually becoming more apparent, like rocks and shallows divulged by the turn of tide. Thus:—

1. *As a cleansing crop*, Roots possess no substantive advantages over any other kind of drilled plant subjected to thorough Horse-Hoeing Interculture; while, again, the shade of their broad foliage, once deemed beneficial to the soil, is now justly denounced as an injurious interception of

that free access of light to the surface, and of air and atmospheric vapour to the internal pores of the vegetable mould, which it is one of the chief ends of modern cultivation to promote in the fullest degree.

2. *As a food for live stock*, chemical analysis, as well as actual experiment in feeding, has determined that of every 100 tons of Turnips or Mangolds carted to the homestead (to the great detriment of the soil, and no less distress of the teams,) about 88 tons weight is *water*, devoid altogether of any animal nutrition whatever; and that the dead weight product, in butcher meat, of a ton of turnip consumed by feeding stock, is very little more than the third part of a single stone, or about 5 pounds! Hence, when Turnips are let to the store-farmer to be fed off the ground, they fetch only from 2s. 6d. to 3s. 6d. per ton, and, in some localities, nothing beyond the manurial benefits resulting from their consumption on the spot.

3. As a much relied on *source of plentiful manure*, organic chemistry asserts and it proves that, at best, this amounts to no more than a partial restoration to the soil of that enormous drain of fertility abstracted in the aggregate by Roots in

their growth—a good yield of Turnips, for instance, consuming nearly thrice as much mineral pabulum as a fair return of wheat; while, further, the time and strength of the draught animals in hauling 100 tons to the fallow field, are expended not only on less than 30 tons of really fertilizing matter, but on more than 70 tons of *caput mortuum* in the condition of absolutely inefficacious moisture.

4. But, be that as it may (many will say), *how palpable the benefit of Roots in the modern system of Stall Feeding!* Now, in reply to this, it may preliminarily be conceded that, in point of fact, a very large amount of butcher meat has come to be manufactured on tillage farms, which could not have been so without an extensive cultivation of Roots; but then, we would in replication enquire, What of the profitable results? Now, in the first place, it is to be noted as a very singular fact that, although Mr. James Caird, the author of "*English Agriculture*," when conducting his statistical enquiries, was desirous to ascertain the annual produce of stock on corn farms generally throughout the kingdom, he was unable to obtain sufficient data for forming any estimate on that point of husbandry; neither is it possible to extract from general Agricultural Literature any

national profit and loss account of Root Feeding. Hence, although every one probably is agreed that that expedient would be ruinously unremunerative but for the manure it produces in aid of the corn crops, it is impossible to determine whether the article thus manufactured is not procured at much greater cost than its real intrinsic value compensates. If, however, we resort to another department of statistics, more successfully examined by the same writer, we do indeed find that the vast amount of capital, skill, enterprize, and superior education embarked on Alternate Husbandry (of which cattle crops are so important elements), has, in the last fourscore years, raised the acreable rent of the tillage districts about 87 per cent; yet, we also learn that, in the grazing counties, where root cropping to any extent is extremely exceptional, and where, comparatively speaking, neither capital, skill, nor enterprize, have generally prevailed, the average rise per acre in the same interval has been 30 *per cent. greater;*—thus leading inevitably to the conclusion, either that the occupier of the mixed husbandry districts, contrary to the common belief, has appropriated to himself a larger proportion of the profits of the soil than has fallen to the lot of his

pastoral brother; or, which is much more probable, that in some branch or other of Alternate Husbandry (in all likelihood, the root growing and cattle feeding department), a large amount of unproductive industry is wasted, to the prejudice of both tenant and landlord. Addressed as these arguments are to the owner and occupier of *improved* property, it is unnecessary here to enter on any question respecting either the past or present merits of Alternate husbandry, as an agent in the amelioration of neglected estates.

5. But *has* not abundant *cereal fruitfulness ever prevailed in conjunction with Root Growing?* Now the statistics of the matter are these: that the average annual produce of wheat per acre since the period when corn began to suffer a divided dominion with Roots, has, on the approximate calculations of Caird, only risen from 3 to 4 bushels, (*i. e.* from 23, or 24, to $26\frac{3}{4}$), and other kinds of grain, in no greater proportion; while, again, it is undeniable that within the whole compass of agricultural evidence, scientific or practical, there are no data whatever to warrant the attribution of this surprisingly small increase (all things considered) wholly or even mainly to the dung products of fallow crops, but data

sufficient to ascribe it chiefly to drainage, to inclosing, to shelter, to the use of better sorts of seed, to extraneous manures, and, though last not least, to the greatly improved methods of tilling the soil which have contemporaneously sprung up.

6. *Is then the farmer to dismiss from his mind all confidence in this hitherto much relied on expedient of Root Husbandry?* To which, the reply may be stated thus: That not by its *use* but its *abuse* has any miscarriage in modern practice been occasioned. For instance: the old arable farming of England throve well (see *after*, ¶ 11, *p.* 15,) yet without any aid from the manurial products of either roots or clover, or any other kind of tilled cattle crop. And when green crops were first proposed to be engrafted on that prior husbandry, the deep thinking JETHRO TULL pronounced with no uncertain sound their adaptation to grazing rather than to cereal management, and furnished, in his own practice, the type of pure corn growing. Thirty years after Tull's death, arose ARTHUR YOUNG, that great apostle of mixed agriculture; and, at a time when the prices of wool, butcher-meat, and dairy-food, afforded much less profit to grazing than now, being only about half their present value (bread

costing about as much then as now), what he taught was this, that in English farming, grazing was of primary, and arable management of only secondary importance. Fully impressed, however, with that imperfection inherent in pure grazing in northern climates, namely, the pinched condition of the stock, both in food and litter, during the rigour of winter, Young inculcated that the proportioned farm, of all others the most profitable, is one possessing, in connection with and subservient to permanent grass, as much arable land under a rotation of roots, clover, and straw crops, as will yield ample food and comfort throughout the cold months to that entire number of animals, and no more, which the grazing acreage will competently maintain during the summer. Guided by the then ordinary acreable yields of tillage produce, Young conceived that a third under permanent grass, and two-thirds under the plough (the latter cropped in equal proportions of—first turnips, second corn, third clover, fourth corn), would form, in most instances, an economical distribution of the area of farms, and hence the origin of the four-field system; but it was of the very essence of his teaching on this subject, that, *not* relative *acreage*, but relative

produce, was to form the basis of apportionment, insomuch that, if from more productive management subsequent to the first acreable arrangement, the tilled part should yield more than enough for the winter sustenance of the summer-kept stock, then the arable division must suffer curtailment by converting an adequate modicum thereof into permanent grass, so as thereby to restore that cardinal requisite,—the equilibrium of summer and winter provender. That the later generations of tillage farmers did not subscribe to this logical, sagacious, and practical advice, is too true; for not only did they succeed in raising heavier crops of both roots and artificial grasses (and this, in itself, of course to their praise) without that success leading them proportionally to increase the grazing, and to lessen the tillage dimensions of their holdings, but they actually converted much of the former into the latter,—and, in particular, augmented so greatly the annual breadth of roots, that from a seventh, a sixth, or a fifth, these ultimately came, as they now most commonly do, to engross a fourth part of the farm. Will any candid agriculturist confidently pronounce that this momentous disregard of the injunctions bequeathed by Tull, the greatest genius in husbandry of any

age or country, and by Young, the Father of English Rural Economy, has not been a very grave error in judgment? or (if that mode of expression be too unqualified) that a more or less modified resumption of the principles and practice inculcated by these two foremost masters in Israel, is not one of the fittest subjects which can occupy the reflections of landlord, agent, and tenant, in a country unrivalled for its climate and soil in permanent pastures, and for the pastoral skill of its rural population, but now open to unrestrained competition in the corn market with foreign regions naturally possessing much more cereal fertility?

7. Meanwhile, those owners whose liberality has most promoted alternate husbandry, will be those in whose breasts the strongest doubts must arise whether, in the face of the larger rental returns of grazing management, it is expedient longer to press forward in the same comparatively ungrateful regime. And as for the occupier, what could he have done more to his possession that he has not done in it? Yet, epidemic pestilence decimates the imposing ranks of his feeding-houses; and physiology tells him that such ever has been, and

ever will be, the inevitable penalty of the unnatural crowding together of animals, especially under cover, unless sanitary precautions be strictly practised of a kind, to all practical purposes, impossible in the modern method of stall-feeding. The fly destroys the seedling turnips, or disease corrupts the matured ones; or, should neither of these too frequent fatalities occur, the heavier the crop the greater the injury done to the tilth of the land by the operation of cartage. The clover seeds refuse to grow, thereby conjointly with the uncertainty of both turnips and mangolds, ofttimes most seriously deranging the preconcerted plans of the season. The soil, saturated with the stercoraceous products of extraneous feeding stuffs of every conceivable kind produces rankness, without strength in the corn stalk; and lodging, and its concomitants of light grain, innutritious straw and smothered grass seeds, are the consequence. Meanwhile contemporaneously with these obstacles to success in the existing form of agricultural practice, all through the kingdom marts are springing up of adventitious manures, economical of labour in distribution on the land, and active in effect. Year after year is producing new implements constructed with consummate mechanical skill, to render till-

age at once more efficient and less costly. Steam even is pressing forward its almost illimitable energies to swell the number of the modern husbandman's agents in field work; and as if all these were not reasons enough for the English farmer reviewing a now antiquated system of management, which, both in weft and woof is unsuitable to the present day, the truth of Jethro Tull's two propositions of, 1st, *Tillage a substitute for manure;* and 2nd, *Successive corn growing not only consistent with the vegetative nature of cereal plants, but with abundant industrial remuneration*, have been re-asserted and re-demonstrated in a manner that will no longer excuse a fair and deliberate hearing, except from prejudice and ignorance.

8. Hence, already it has been mooted by leading agriculturists in the corn counties, actuated doubtless by the doubled value of grazing products in the wool, the butcher, and the dairy markets of the last eighty years, and by the greater industrial economy of grass management, indicated in the greater comparative rise of rents in the pastoral districts,—that *a reformed system, founded more broadly on grazing husbandry, must now be pursued.*

9. Other practical men, of equal professional

authority, also would diminish the proportion of roots, not, however, to increase the grass land area, but rather the corn-growing basis, in the belief that untrammelled from the alternate system, corn could, by such a change, be cultivated at less cost,and to greater profit; these holding, 1st, that any soil may, by the due use of modern tillage mechanism, be kept clean and in good heart with comparatively little or even no dependence on cattle crop manure; and 2ndly, that provided a soil *be* kept constantly clean and hearty, no matter by what cultural processes, there ought to be no dread by either landlord or tenant of returning to an improved adaptation of that principle of pure corn farming successfully practised in England before the introduction of alternate husbandry—these latter reformers being, in truth, followers of Jethro Tull, as the former are of Young.

10. But whether *Young's* or *Tull's* principles are to prevail, or whether both are destined, under different circumstances, to run contemporaneous courses, Tull's two propositions, stated above in ¶ 7, are equally important in either case, because, in a reformed practice of mixed grazing and tillage husbandry, the policy would be to make tillage

play its maximum fertilizing function in the arable division of the land without any, or at most, with the minimum manurial aid, and thereby preserve the greatest possible quantity of the dung-court products for application to that part of the farm which, devoted to permanent grass, can take no benefit from tillage: of course, in any new system of pure corn farming, manure producing crops could largely, if not wholly, be dispensed with, if it be true that thoroughly tilled, cleaned, and dried corn land is largely or even wholly independent of manure.

11. Doubtless, however, the notion that uninterrmittent corn growing can ever be adopted in any system of husbandry, consistently with the lasting interests of either the lord or the tiller of the soil, will, by many, be scouted as simply monstrous or incredible. Is it not, nevertheless, a matter of indisputable statistics that, prior to the middle of the last century, the tillage farming of England, as already asserted, was both non-alternate and all but non-manurial? (See also ch. III.) Is it not also true that while such was really the national system of corn growing, so plentiful was the yield that, after supplying the wants of a rapidly-increasing population, there was

still enough, and to spare, to form an important branch of export commerce, and that too so wonderfully expansive as to rise from $8\frac{1}{2}$ millions of quarters of wheat, barley, and malt, shipped in the period between 1700 and 1725, up to nearly 14 millions exported in the next twenty-five years, besides no inconsiderable quantities of oatmeal and rye? and although the question whether, since the alternation of green crops with corn, the aggregate cereal produce of the kingdom has increased or diminished, is involved in great doubt, certain it is that no augmentation (if, indeed, there be not an actual falling off), consequent on alternate husbandry, can, on any known statistical facts, be asserted.

12. Hence the old idea, that successive corn growing is a violation of the natural laws of vegetation or of fertility in the soil, already unequivocally disowned by both physiologist and chemist, as the spurious offspring of false induction, must be abandoned by the enlightened modern farmer also, leaving his mind free to form a fair and impartial judgment on that existing body of evidence, which not merely goes to demonstrate negatively the innocuous consequences, physically, of unintermittent cereal culture,

but positively its remunerative and practical advantages.

13. What that evidence is, in its physical, operative, and economic bearings, will be found systematically compiled, for the first time, it is believed, in English agricultural literature, in the following little work. Long entrusted with land management in both divisions of the island, two maxims have ever guided the author's not unsuccessful efforts to promote the reciprocal interests of landlord and tenant, namely, that to stand still in agricultural improvement, is practically to retrograde; but that, on the other hand, innovation is not improvement, unless it be profitable. Hence the leaven, at least, of a wholesome and progressive experience is mixed up with the following chapters, be their demerits in other respects what they may.

CHAPTER II.—TULL'S AGRICULTURAL BIOGRAPHY.

Tull received a University Education, and was bred to the Bar.—Obliged to abandon his Profession from constitutional ill health.—In 1701 began to Farm an Inheritance in Oxfordshire.—There became the Inventor of the first English Drill Sowing Machine, and of Drill Husbandry.—His own Account of the circumstances which led to these inventions.—Their Success.—Obliged to Travel abroad for his health.—Observed the Husbandries of Continental Countries.—Returned Home, and began to Farm another Inheritance in Berkshire.—Studied the Natural Sciences, and resolved on Adopting a Reformed Method of Husbandry.

The little that is known of Jethro Tull's personal history, is almost exclusively connected with his agricultural celebrity. He inherited two small estates, one in the county of Oxford, the other in the hilly district of Berks, on the confines of Wiltshire. Receiving a University Education, he was called to the Bar, which, however, he relinquished in consequence of chronic ill health, ultimately of the most acute kind. Thus precluded from his chosen profession, in a happy hour for Agriculture, he betook himself, about the year 1701, to the farming of his Oxon estate, and there invented the first English Drill Sowing Machine, and was the first to practise that method of Drilling, which has become so completely an integral part of British Husbandry.

The many authors who have treated of the progressive improvement of steam mechanism from its first very imperfect state, all follow each other in relating, with devout particularity, Watt's own modest account of the inductions which resulted in his first great invention—the separate condensing apparatus.

Now, signal in its benefits to manufactures and commerce as was this beautiful contrivance, who shall assert that agriculture, and through agriculture, mankind, were less beholden to TULL for that invention of his, in the mechanism and practice of drill sowing, which, unquestionably, has since become the basis of every improvement in modern British husbandry? It is fitting, therefore, that the origin of this great English cultural device should form an early topic of the following treatise, and should be related in TULL's own words:

"I should not," he says, "trouble the reader with an account how accidentally it (the drill) was discovered, were it not to shew, that the knowledge of a thing which seems despicable or impertinent, may unexpectedly become useful at one time or other.

"When I was young, my diversion was music: I had also the curiosity to acquaint myself

thoroughly with the fabric of every part of my organ; but as little thinking that ever I should take from thence the first rudiments of a drill, as that I should ever have occasion of such a machine or practise agriculture; for it was accident, not choice, that made me a farmer, or rather many accidents which could not then possibly be foreseen.

"It was my chance afterwards to have a large farm in hand, which I could not well dispose of; and it being about the time when plough servants first began to exalt their dominion over their masters, so that a gentleman farmer was allowed to make but little profit of his arable lands; and almost all mine being of that sort, I resolved to plant my whole farm with St. Foin; but the seed of it being scarce, and dear, and very little of it good, I found it would be very difficult to procure a sufficient quantity to sow, at seven bushels to each acre, which were usually sown. Whereupon I began to examine whether so great a quantity of seed was absolutely necessary; and whether the greatest part of the seed sown, did not commonly miscarry, either by its badness, or from being buried too deep, or else lying on the ground uncovered: and I observed in several fields of St.

Foin, sown with that proportion of seed, that in those parts of them which produced the best crop, there were (as I counted them when the crop was taken off) but about one plant for each square foot of surface; and yet the number of seeds in seven bushels sown on each acre, being calculated, amounted to one hundred and forty to each square foot; and, what was yet more observable, in other parts of the same fields, where a much less number of seeds had miscarried, the crop was less. Then after I had learned perfectly how to distinguish good seeds from bad, and had, by many trials, found that scarce any, even of the best, would succeed, unless covered at a certain exact depth (especially in my strong land) and had also found the reason of this nicety, I employed people to make channels, and sow a very small proportion therein, and cover it exactly.

"This way succeeded to my desire, and was in seed and labour but a fourth part of the expense of the common way, and yet the ground of seed was better planted.

"Ten acres being so well done, I did not doubt but a thousand might have been as well done in the same manner; but the next year as soon as I

began to plant I discovered that these people had conspired to disappoint me for the future, and never to plant a row tolerably well again: perhaps jealous, that if a great quantity of land should be taken from the plough, it might prove a diminution of their power: I was forced to dismiss my labourers, resolving to quit my scheme, unless I could contrive an engine to plant St. Foin more faithfully than such hands would do.

"To that purpose I examined and compared all the mechanical ideas that ever had entered my imagination, and at last pitched upon a groove, tongue, and spring, in the sound-board of the organ. With these a little altered, and some parts of two other instruments as foreign to the field as the organ is, added to them, I composed my machine. It was named a drill; because when farmers used to sow their beans and peas into channels or furrows by hand, they called that action drilling.

"It planted that farm much better than hands could have done, and many hundred acres besides; and thirty years' experience shews, that St. Foin, thus planted, brings better crops, and lasteth longer than sown St. Foin.

"This drill has also been used almost as long in

planting most sorts of corn for hand-hoeing; and these last nine years for horse-hoeing."

Compelled, ten years after, to resort to the continent for his health, TULL let his farm, and proved the goodness of his previous management by obtaining a considerable and permanent advance of rent.

Abroad, he resided for several years both in Italy and in one of the Mediterranean Provinces of the south of France (Languedoc), and from his observation of the husbandries of these countries. conceived three great propositions in Agriculture, which will afterwards be more particularly dwelt on, namely :—

1. That interculture amongst the growing crops is a necessary operation in well conducted farming;

2. That adequate tillage is not only an economical substitute for manure, but

3. That thorough tillage is also competent, with or without the aid of manure, to secure the profitable growth of any given species of cultivated plant, year after year, in succession.

The circumstances under which he arrived at these conclusions afford a beautiful instance of inductive reasoning, and are thus related by him :—

"The vines of low vineyards" (*i. e.* vineyards where the plants are kept, by pruning, in the condition of low shrubs), "hoed by the plough, have their heads just above the ground, standing all in a most regular order, and are constantly ploughed in the proper season; these have no other assistance but by hoeing, because their heads and roots are so near together, that dung would spoil the taste of the wine they produce, in hot countries.

"From these I took my vineyard scheme, observing that indifferent land produces an annual crop of grapes and wood without dung; and though there is annually carried off from an acre of vineyard as much in substance as is carried off in the crop of an acre of corn produced on land of equal goodness, yet the vineyard soil is never impoverished unless the hoeing culture be denied it: but a few annual crops of wheat, without dung, in the common management will impoverish and emaciate the soil.

"I cannot find either in theory or practice any

other good reason for this difference, except that the vineyard-soil is more pulverised by hoeing.

"The soil of the vineyard never can have a true summer fallow, though it has much summer hoeing, for the vines live in it and all over it all the year; neither can that soil have benefit from dung, because although by increasing the pulverisation it increases the crop, yet it spoils the taste of the wine. The exhaustion of that soil is, therefore, supplied by no artificial help but hoeing; and by all the experience I have had of it, the same cause will have the same effect upon a soil for the production of corn."

Elsewhere he relates, that these vineyards have occupied the same ground unchanged for many centuries, maintaining, without manure, an undiminished fertility.

Pondering on these things, he returned home; and impressed also with the well-founded conviction, that the then prevailing ancient husbandry of England was extremely defective in operative details, he resumed his agricultural pursuits, but now on his Berkshire property, and forthwith began to give effect to his ideas of what could be done in the reformation of practical routine

culture.* But, in order to acquire the light of science for his guidance in the new paths he was about to enter, he first made himself master of the many important discoveries in Physics and Physiology which Bacon, Newton, Ray, Hales, Grew, Bradley, Evelyn, and others, had so largely given to the world in that or the preceding century, —acquisitions which, joined with his previous actual experience in farming, and the enlargement of his views promoted by travel, eminently qualified him every way for the successful execution of such a design.

* In an admirable Review of Tull's Husbandry, in the "*Farmers' Magazine*," of 1855, (Vol. viii, third series, p. 340,) and generally attributed to the pen of Mr. J. A. Clarke, of Long Sutton, Lincolnshire, it is said that Tull was abroad twice, and that the Berkshire farm (named "Prosperous") was a hired one. Regarding these points, we will only observe, that various circumstances mentioned in Tull's Book, shew, that, at least eventually, the farm became his own property, (see after, chapter x,) and whether he travelled twice or only once, is perhaps immaterial.

CHAPTER III.—THE OLD TILLAGE HUSBANDRY OF ENGLAND.

The Husbandry of Tull's time was part Pastoral and part Tillage.—The Management of the Tillage portion of the Farm of that day described.—Was exclusively Cereal in its nature.—The Bare Fallow.—The Defects of the System.—These, however, in operative details, and not in principle.—The Old Economy of Manuring very inept.—Tull's belief that the benefits of the Bare Fallow were due chiefly to the thorough Tillage, and not to the imperfect Dunging it received.—His conception of applying the thorough Tillage of Vineyard Husbandry to the growing Field Crops.—The then recent Introduction of Turnips and Clover into English Farming adverted to.—Tull actually applies the Vineyard Interculture to Turnips.—He thereby became the Inventor of the existing form of Root Tillage, and of the first English Horse Hoe.

It has been seen in the preceding chapter, that the change which Tull sought to accomplish in Agriculture was not the subversion of the main principles of the then existing husbandry of England, but only the reformation of its methods; and there will, therefore, be found both aptness and advantage in next recounting what the leading characteristics of that ancient husbandry were.

First then, the old agriculture of England was at that time—as it ever had been and still is—mainly pastoral. Since the beginning of the 18th

century (the period now in question), a considerable acreage has been subtracted from grazing land and added to tillage; but even now, permanent pastures stand in nearly equal proportions the entire kingdom over.—*Caird's English Agriculture*, pp. 520, 521, 522.

Varying, however, in different localities, from a maximum of three-fourths to a minimum of one-half, the then English farm had a constant portion under grass, into which predominant grazing division the plough never entered; while, again, the minor tillage portion, of which only we shall hereafter speak, was as entirely devoted to corn growing, exclusive (an occasional pulse crop excepted) of everything else, and consisting of a routine of wheat or rye, barley, oats, or pease, arranged in successional order among themselves, somewhat differently in different soils, but never alternated with any other kind of plant.

The bad farmers of the day made the cycle larger by repeating one or other of its members more than once; but what has been stated was the usual routine of good tillage farming.

In this system, however, two phenomena were, in all districts alike, constant and remarkable; for, first, the acreable produce of each

succeeding crop of the cycle was seen to decrease in a compound ratio,—step by step, downward; while, secondly, the growth of weeds, year by year, became more excessive; and, therefore, our forefathers were fain to adopt that remedial expedient originally introduced by the Romans, namely, the still common bare fallow, whose offices were not only to relieve the land of the accumulated weed of the previous cycle, but to give to the land the fertilisation and cleansing of a periodical summer tillage, as well as to allow that inherent elaboration of nutritive matters, which is a property of all good soils, to accumulate for a year without abstraction by any crop. Through this threefold means of amelioration the soil became periodically cleansed and recruited; and while the practice was inadequate to prevent a lessening yield in the succeeding crops of every cycle,—each cycle, as an aggregate, nevertheless, from century to century, maintained not only an undiminished, but, concurrently with the improving agricultural industry of the nation, an actually increasing mean in corn productiveness throughout the country.

In addition to what has already been stated in ¶ 11 of the Introductory Chapter, the following Table will also be found illustrative of this subject.

TABLE I.

SHEWING THE ESTIMATED ACREABLE CORN PRODUCE OF ENGLAND AT VARIOUS PERIODS.

	Wheat. Bush.	Barley. Bush.	Oats Bush.
1. In the 13th century*	12	24 ?	24 ?
2. Latter part of the 16th*	16 to 20	36	32 to 40
3. Third quarter of the 18th, at which period the old corn husbandry still prevailed†	23 to 24	32	36
4. Middle of the 19th‡	$26\frac{2}{3}$	38	44

Next, of ANCIENT MANURING; and of old, the practice stood thus:—Of stall-feeding, there was next to none, and very little winter housing of live stock; and hence the product of dung was comparatively insignificant both in quantity and quality. Very usually a stream of surface water was directed through the farm yard, to float its best riches to some favoured meadow; and as the permanent grass closes always came in for a

* Sir John Cullum's "History of Hawksted;" and also the Description of Britain in Elizabeth's reign, prefixed to "Hollingshed's Chronicle," as quoted in Lankaster's "Food of Man," Lib. En. Kno., p. 43; and Hoskyn's Introductory Essay in Morton's Cyclopœdia of Agriculture.

† Young's Ten Months' Tour through the North of England, 1770.

‡ Caird's English Agriculture, pp. 474 and 522.

large share of the solid dung to ensure a good shear of hay, what remained to be worked up with each year's bare fallow of the tillage land, was very inconsiderable: but to supplement this, in some degree, it was very customary to spread out dry straw in the lanes, to be trodden under foot into a sort of compost, and then carted to the ploughed fields.

Under these circumstances, is it wonderful that a thinker of TULL's capacity should have attached extremely little value to so feeble a process of stercoration to the corn crops, as has been here related? or that in reasoning on the renovated fertility effected by the bare fallow, he should have arrived at the conclusion, that *not* to the manuring, but, mainly, to the working of the land and the abatement of weeds, joined with a year's rest from cropping, was the renewed increase of the soil due: or need we wonder that he should have convinced himself, that, if by any means he could introduce into the midst of the growing corn, an interculture analogous to that of the vineyards which, besides communicating to the soil the specific benefits belonging to thorough tillage, should also suppress the prevailing most noxious foulness of the land,

then, as in the vineyard, an unfluctuating productiveness would ensue, without the aid of manurial applications; nay, without even a periodical fallow rest. To illustrate this most important point of our statement, with the author's own words, we quote, as hitherto we have been doing, from his agricultural work, entitled "*Horse-hoeing Husbandry*,"* as follows:—

"I own," he says, "I took the first hints of my horse-hoeing culture from the ploughed vineyards near Frontignan and Setts, in Languedoc; and after my return to England, having land come to my hands, I improved those hints by observing, that the same sort of vineyard tillage bestowed on potatoes and turnips, had the same effect on them as it had on these vines;" "and then," he continues (referring to an accidental field observation, which he had previously related), "the mentioned row of barley, adjoining to the horse-hoed turnips, confirmed me in the principles, which, by arguing from effects to their causes, I had formed to myself; and my practice, ever since, has been a further confirmation to me of the truth of the same principles."

* See Chapter iv.

Meanwhile, although Tull himself never sought to revolutionize, but only to improve the old husbandry of England, an innovation which has since grown into vast magnitude had begun to gain ground; to wit, the alternation of turnip and clover crops with corn, on tillage farms. At first, Tull fell into the general current flowing in that new direction; and, inasmuch as he did so, to that fact is attributable the greatest event in operative husbandry which has hitherto happened in these islands.

Let us endeavour to explain this succinctly. In his Oxfordshire farming, Tull, as we have already seen, invented, and made use of a drill-machine to sow his various crops; and thus he became *the acknowledged father of* Drill Husbandry. By this expedient he attained three objects: first, the more equable deposition of the grains; 2ndly, a great saving of seed,—(and thus *he was the father also of* Thin Sowing;) 3rdly, the promotion of the process of weeding, both by the hand and hand-hoe. And of this branch of his practice, the corn-drilling of the present day, as contradistinguished from that sort practised in the fallow crops, is the living representative.

But that improvement of Tull's, which has become the great leading feature in modern farming, consisted in this: that in cultivating his fallow crops, after his return from abroad, he not only persisted in his prior practice of drilling, but so widened the spaces between the rows as to admit the passing between them of an implement contrived by himself, to be drawn by horses,—*in order to impart to the growing plants the same intereulture he had seen so beneficially used amongst the vines of southern Franee.* This process he termed horse-hoeing; and in like manner as he was the author of corn-drilling and of thin sowing, *so likewise was he the inventor of all that is excellent in* Fallow-crop Tillage.

CHAPTER IV.—OF TULL'S BOOK, AND OF HIS FARM.

After perfecting Drilled Turnip Culture on his own Farm, Tull abandoned it for pure Cereal Husbandry.—His practical success became much noticed.—Urged by leading Agriculturists, he published his Principles in his Book, entitled "Horse-Hoeing Husbandry."—His Farm described.—Its Extent about 200 Acres.—Its Quality a thin Chalk Soil.

But although, from what has been related in the last chapter, Tull was the undisputed father of that system of interculture in roots which has obtained for these and other drilled cattle provender the somewhat anomalous term of fallow crops; and although he himself successfully organized drilled and horse-hoed turnip growing on his own farm, he eventually abandoned that practice, as well as the growth of tilled clover, and fell back on the old system of pure corn-husbandry; not scrupling, however, to make havoc of its antiquated tillage expedients, and boldly to substitute a more efficient operative routine in their place.

In this very arduous and difficult course—the more so from the insolent and intractable habits of the agricultural labourers of that day—he most perseveringly continued for many years, without entertaining any desire to proselytize others

to his system. At last, urged by leading men of the day connected with the agricultural interests of all the three kingdoms (who, visiting his farm in great numbers, had seen with conviction the extraordinary practical talent, as well as success, displayed in his new method of farming), Tull wrote, and published by subscription, an elaborate exposition of his system, under the following title: "The Horse-Hoeing Husbandry, or a Treatise on the Principles of Tillage and Vegetation, wherein is taught a Method of introducing a sort of Vineyard Culture into the Corn Fields, in order to increase their product and diminish the common expense. By JETHRO TULL, of Shalborne, in the county of Berks. 1733."*

Alas! the whole, as he states in the preface, "was written in pains of the stone and other diseases as incurable and almost as cruel."

"Connection," he adds, "cannot be expected in a book composed of Notes written at different times, some in one year, some in others, as something new flowed from a different practice from what was common. Besides, as I was by sickness

* Cobbett's Edition of 1829 is the best, and indeed only one now in print.

incapable of assisting when it was transcribed for the press, when many notes were to be inserted, my scribe not understanding their marks, misplaced many of them, some in the text, some in the margin, some in the wrong Chapters, many he left out, and more being mislaid which he did not find; among which last were the several weighings of my drilled crops and the neighbouring sown crops.

"Several things caused the want of method. My scribe was so little skilled in country affairs as sometimes to set the cart before the horse, as he does, where he places the hoeing of turnips before the planting of them: but I presume this mistake will not be followed by any practiser, and then nobody will be injured by it, or by any such like Hysteron-Proteron to be found in the Chapter of Wheat, or elsewhere in the book."

Under these touching circumstances, it is not surprising that the work, though a rich mine of both theoretical and practical instruction, should be so immethodical as really to be unfitted for general perusal; and, consequently, an endeavour shall, in the sequel, be made, by copious quotation properly arranged, to epitomise what in it relates to that successive mode of corn culture which the

author himself practised; and in doing so, we shall be enabled to furnish a guide to those who may choose to test, by actual experiment, the pretensions of Tullian farming to a place in the corn-husbandry of England. In the narrative also there shall, from time to time, be introduced some of the leading principles of modern Agricultural Physiology and Chemistry, in order to shew the surprising harmony of Tull's practice, with subsequent discovery in the laws of vegetative nature.

To the practical reader it is important also that the agricultural circumstances of the stage on which the "New Husbandry" (as Tull's system came to be called) was invented and enacted should be known; and thus he himself describes his farm:—

"I am sorry that this farm, whereon I have only practised horse-hoeing,—being situate upon a hill that consists of chalk on one side, and heath-ground on the other,—has been usually noted for the poorest and shallowest soil in the neighbourhood.

"It is both known and seen to be one of the highest farms in all that part of the county of Berks where it lies; it may be seen at ten or twelve miles' distance, and was a more remarkable

eminence before the trees were blown down by that memorable storm in the year 1703.

"The bulk of the land belonging to this farm is, on the south side, for near a mile in length, always called Bitham Hills, and are, for the most part, declining grounds, a sort of *graciles Clivi*, being all on a chalk: in dry weather the whole staple looks of a white colour, it is full of small flints, and smaller chalk-stones: below these hills is a bottom, where are some grounds upon a chalk also, but had not then been used in hoeing, having lain with St. Foin thirteen or fourteen years. On the west side all the land is called East Hills, being on the east of the farms to which they all formerly belonged. On the north-west side is a high field, called Cook's Hill, and is the only field of my farm that is not upon a chalk; it is a very wet spewy soil of very little value, until I made it dry by ploughing across the descent of the hill.

"This soil is all too light and too shallow to produce a tolerable crop of beans."*

* "It was situated," says Cobbett, speaking of Tull's farm, "at a place called Prosperous (probably so called from his great success), in a tract of very indifferent land lying on the north side of the Hampshire hills, near the borders of

Its extent was probably about 200 acres. Ultimately he kept no store animals, not even sheep; and besides a team of horses, occupied chiefly in the business of a tile kiln, he used oxen only to work his farm, or rather castrated bulls, these being, he says, "hardier than oxen, though of lesser size."

Wiltshire, but being itself in the county of Berks. It is, I believe, in the parish of Inkpen. I visited it in the company of Mr. Budd of Newbury, who had visited it long before with Arthur Young, who, like me, visited it in the character of a pilgrim, and in honour of the memory of the real founder of every recent improvement that has been made in the agriculture of England."—*Cobbett's Treatise on Cobbett's Corn, as quoted in Loudon's Encyclopedia of Agriculture, p.* 1208.

CHAPTER V.—OF MANURES.

The Principles of Modern Science respecting them premised.—Extraneous Manures.—The Grosser kinds, Marling, Liming, &c.—The more concentrated kinds, Salt, Nitrates, Guano, &c.—Neither of these classes of Fertilizers used by Tull.—Dung Manuring.—This kind only practised by him.—Its Physical and Chemical Action on the Soil.—Tillage an important Substantive Means of obtaining "Manurial" Matter from the Atmosphere.—Tillage alone competent to promote profitable Fertility in Successive Corn Growing.—Tull's Practice based on that Principle.—But he laid down no General Rule against the Use of Manures in Aid of Tillage. Warned the Manuring Farmer, however, that Great Produce and Great Profit were not necessarily synonymous.—His maxims respecting Manures quoted in his own words.—Recommends Small and Frequent Applications rather than Heavy Single Manurings.—Professor Way quoted.

Based as Tull's precepts and practice were upon his own notions of the relative values of tillage and manuring, as fertilising agents, it will, in order to test and demonstrate the validity of these, be necessary in this chapter to go somewhat into the rationale of manures as unfolded by modern science; and in doing so we would premise, trite though it be, the following proposition: that the constituents of all plants are derived from the soil, on the one hand, by means of the roots, and from the atmosphere, on the other, through the agency of the leaves and other green surfaces.

We shall afterwards have occasion to point out,

that a very important part of the nutriment yielded by the soil to plants is, in fact, an atmospheric deposit, more or less promoted by tillage. In the meantime, however, we shall exclusively consider what may be called the non-atmospheric constituents of vegetative growth insumed by the roots; these being of a twofold kind; first, inorganic substances derived from the purely mineral matters of the ground, by means of natural chemical decomposition; and, secondly, substances, eliminated by the putrefactive decay of vegetable or animal (*i. e.* organic) remains, forming usually a minor, but still most important part of the general constituency of soils.

Normally, however, the organic admixture is not indispensable to vegetation; for experiment has conclusively proved, that a soil from whence all traces of vegetable or animal remains have been removed, will, if exposed to purely atmospheric agency only, support vigorous vegetation.

Now, although unfruitfulness in soils may be caused by several circumstances, the most common one is, not an absolute deficiency of vegetative food, but inability to generate it, from year to year, in such abundance as is necessary to evolve that abnormal exuberance of growth

in plants which alone will repay the labour of the husbandman. Further, we know that there are numberless instances, where, independently of ordinary dunging, the wanting or deficient nutriments may adventitiously and profitably be supplied, as is done in a gross way by marling, &c., or more compendiously by the use of concentrated appliances, such as salt, gypsum, guano, ammoniates, nitrates, &c.

But in Jethro Tull's practice, none of these means of promoting vegetative increase, by *extraneous* fertilisers applied to the soil, obtained: the question which he raised as to the use of, or abstinence from, artificial manuring, having regard only to stercoraceous matters of the ordinary kind, viz.: the products of the dung court, or night-soil procured from the neighbouring town.

Let us next, then, in order the better to discover Tull's conceptions on the subject of manures, examine the theory of stercoraceous manuring; and at all hands it is conceded to be, in principle, a mere imitation of that procedure of nature whereby (altogether independently of human agency) the remains of plants and animals are universally commingled with the staple; the office

performed by the matters, artificially or naturally deposited, being as follows :—

1. All animal tissues are derived (directly by herbivors, and indirectly by carnivors through the flesh of their herbivorous victims) from plants ; and as all plants, at least the terrestrial tribes, obtain the ingredients of their various parts both from the soil and from the atmosphere, so therefore, when organic exuviæ (whether they be corporeal, as the dead parts of vegetables or animals, or excremental, as the fæces and urine of the latter) resolve themselves, by putrescent decomposition, into their more elemental conditions, they are thereby simply restoring to the earth or air those elements of vegetative growth of which plants and (through plants) animals were formed, to be again insumed and assimilated into fresh organisms.

2. But to assign to this process of putrefactive manuring, whether natural or artificial, its full attributes in fertilization, it must be added that between some of the substances produced by organic decay, on the one hand, and the indigenous inorganic matters of the soil itself, on the other, a certain chemical reaction ensues (the "pulverisation"

of Tull, and especially promoted by concomitant thorough tillage of that kind which he invented), by virtue of which the inorganic pabulum is more abundantly eliminated; and thus, then, stercoraceous manuring is both *contributively* and *stimulatively* beneficial.

Now, although the then state of natural knowledge did not enable Jethro Tull to trace these principles nearly so far as has since been done, he allowed to dung manuring precisely the same practical effects as have just been shortly stated. On the one hand, he held that it yielded, although in small proportion, "*earths*" or "*salts*;" thus assigning to it a contributive office: on the other hand, its stimulative property he thus defines: "All sorts of dung and compost contain some matter which, when mixed with the soil, ferments therein; and by such ferment, dissolves, crumbles, and divides the earth very much;" and although these terms, literally interpreted, import physical functions, yet it is very certain, from the whole context of his book, that he himself conceived the phenomena to which they are applied to be something more than that, namely, a chemical reaction, although science had, in that day, furnished him with no adequate phraseology by which to express his conceptions.

At this stage of our statement, it would be inexpedient to go into Tull's still greater induction, namely, that by means of thorough tillage, such as he invented and practised, the very atmosphere itself can be made abundantly contributive to the soil of what science has since determined to be one of the most precious ingredients of fertilization which naturally or artificially can be administered to plants. Enough at present to say, that a chief element of Tull's new method of husbandry was based on a deep practical knowledge of all these various relations and effects of manuring and tillage; and that in his vigorous and calculating mind, this question underwent full consideration, namely, whether *much* manure and relatively *little* tillage,—or *less* manure and *more* tillage,—or *no manure at all* except what could be drawn from the air, but *much* tillage, was most remunerative in pecuniary results. In his own matured practice, this greatest of husbandmen adopted the last alternative even in successive corn growing; and thus, upon a farm of poor land demonstrated the proposition which general considerations had suggested to his mind,—that tillage was not only theoretically, but *practically* and profitably, an entire substitute for dunging. *Indeed, as has*

already been seen, the old tillage husbandry of England, which Tull sought to reform, was itself all but entirely unmanurial.

Tull's genius, however, was no less cautious and deferential than enterprising and bold; for, again and again does he warn disciples that diversified circumstances would demand at their hands diversifications in their practical application of this, as well as all the other great principles which he taught. Accordingly, as an abstract question, he left the use or disuse of manures entirely open, with this most reasonable warning, that large produce and large profit are not synonymous terms; that a less crop more economically obtained may pay better than a heavier one procured at greater expense; and that usually it would be found, on careful investigation, that the money expended in the use of manures would have been more advantageously spent in additional tillage.

Looked at in these lights, therefore, Tull's generalisation of Tillage, a substitute for Manure, loses in abstract catholicity what it gains in practical flexibility; and although, probably, no part of his new husbandry so much stirred up the enmity and opposition of the prejudiced and ignorant, as this supposed heretical doctrine of

growing corn without dunging, there is none really less calculated to deter the most practical man of the present day from entering on Tullian farming, if, in its other main departments, he deems it eligible.

How consistent, for instance, with sound sense and practical judgment are the following passages: "I have made," says Tull, "many trials of fine dung on the rows, and, notwithstanding the benefit of it, I have, for these several years past, left it off, finding that a little more hoeing will supply it at a much less expense, than that of so small a quantity of manure, and of the hands necessary to lay it on, and of the carriage."

"The almost only use of all manure, is the same as of tillage, viz., the pulverisation it makes by fermentation, as tillage doth by attrition or contusion; and with these differences, that dung, which is the most common manure, is apt to increase weeds, as tillage (of which hoeing is chief) destroys them, and manure is scanty in most places, but tillage may be had everywhere. Another difference is, the vast disproportion of the price of manure and that of tillage.

"I have never affirmed that part of the necessary degree of pulverisation made by tillage alone, with-

out the salts of manure, will have the same effect as the whole necessary degree of pulverisation made by tillage, and those salts together will; neither have I said that tillage alone can pulverise to that degree in all sorts of land."

Keeping no live stock but labouring cattle, the accumulations of his dung court must needs have been insignificant; and the whole he preferred applying to his permanent St. Foin lands and pastures.

It may be added, that he strongly inculcated, that where dung is used, it should be distributed in repeated small quantities during the actual growing of the crops (a process which his method of tillage, we shall find, renders very practicable), rather than in one large application antecedent to sowing.

We conclude this chapter with the following quotations from a paper of Professor Way, in the xiii vol. of the Royal Agricultural Society's Journal, p. 141: "Now, although," he says, "it has been a constant axiom in the instructions of chemists to farmers to return to the soil what the crops remove (and every candid agricultural chemist will own, that at the outset of his career he has somewhat overrated the importance of

literally fulfilling this obligation), it is certain that most soils of fair quality contain an amount of the different mineral substances far greater than is necessary for many successive crops of the most impoverishing character." So that here something more than a mere suspicion is raised, that so far as the inorganic vegetative nutriment of soils is concerned, the expensive process of manuring may be a very unprofitable act of supererogation.

"The fact," he adds, in another paragraph, p. 142, "is, that there is an almost unlimited supply of the mineral requisites of plants in soils, but that the great agricultural problem is to get at them,—to render them available; and here again it seems reasonable to suppose that abundant cultivation, which lets in carbonic acid and ammonia to the soil, may, by that very act, be providing the potash and phosphate of lime, which the former (the carbonic acid), and the silica which the latter (ammonia) are endowed with the power of dissolving, and presenting to the roots of plants."

Now, in subsequent chapters, we shall see that, both theoretically and practically, abundant cultivation *is* adequate to promote remunerative fruitfulness in soils, without the addition of any extraneous aid from solid manuring.

CHAPTER VI.—§ I. THEORY OF TILLAGE GENERALLY.

Definitions of Tillage. Its Physical Effects in Consolidating too Porous Soils, and Opening Close Textures.—The Openness of Soils Indispensable to the Condensation of Dew.—Experimental Proofs of this.—The Fertilizing Effects of the Atmosphere on Soils.—An Instance cited from Evelyn.—Thompson's Modern Discovery of the Chemico-Absorbent Power of Soils, cited.—Way's further Discoveries connected with the same Phenomenon.—Liebig cited on the same subject.—Theory of its Operation Relatively to Vegetation.—The Manuring Influences of the Air and Rain Dwelt on.—These in Proportion to the Tilth of Soils.—Way's Recognition of the Soundness of Tull's "Convictions" in Agricultural Philosophy.—Practical Deductions Arising out of the Theory of Atmospheric "Manuring."

§ II. OF HORSE HOEING OR INTERCULTURAL TILLAGE.

True Tullian Horse-Hoeing Defined.—Its Thorough Eradication of Weeds.—Its Signal Effects on the Growth of Plants.—Keeps Plants Moist in Dry Weather.—The Physical Causes of this Explained.

§ I. OF TILLAGE GENERALLY.

1.—*Its Physical Effects on the Texture of the Soil.*

"TILLAGE," says TULL, "is the breaking and dividing the ground by spade, plough, hoe, or other instruments, which divide by a sort of attrition or contusion, as dung does by fermentation."—"Dung, without Tillage, can do very little; with some tillage does something; with much tillage pulverizes the soil in less time than tillage

alone can do; but the tillage alone, with more time, can pulverize as well." Again; "tillage (as well as dung) is beneficial to all sorts of land. Light land, being naturally hollow, has larger pores, which are the cause of its lightness. This, when it is by any means sufficiently divided, the parts being brought nearer together, becomes for a time, bulk for bulk, heavier; *i. e.* the same quantity will be contained in less room, and so is made to partake of the nature and benefits of strong land, viz., to keep out too much heat and cold, and the like.

"But strong land being naturally less porous, is made for a time lighter, as well as richer, by a good division; the separation of its parts makes it more porous, and causes it to take up more room than it does in its natural state, and then it partakes of all the benefits of lighter land.

"The finer land is made by tillage, the richer will it become, and the more plants it will maintain.

"It has been often observed that when part of a ground has been better tilled than the rest, and the whole ground constantly managed alike, afterwards, for six or seven years successively, this part that was but once better

tilled, always produced a better crop than the rest, and the difference remained very visible every harvest.

2.—*The Effects of Tillage in the Condensation of Dew.*

" One part being once made finer, the dews did more enrich it; for they penetrate within, and beyond the superficies, whereto the roots are able to enter. The fine parts of the earth are impregnated throughout their whole substance, with some of the riches carried in by the dews, and there reposited ; until, by new tillage, the insides of those fine parts become superficies ; and as the corn drains them, they are again supplied as before : but the rough large parts cannot have that benefit ; the dews not penetrating to their centres, they remain poorer. *Minus habentibus minus datur, et vice versa.*

" To demonstrate that dews moisten the land when fine, dig a hole in the hard dry ground, in the driest weather, as deep as the plough ought to reach : beat the earth very fine, and fill the hole therewith ; and, after a few nights' dews, you will find this fine earth become moist at the

bottom, and the hard ground all round will continue dry.

"Till a field in lands, make one land very fine by frequent deep ploughings, and let another be rough, by insufficient tillage alternately; then plough the whole field cross-ways in the driest weather, which has continued long, and you will perceive, by the colour of the earth, that every fine land will be turned up moist, but every rough land will be dry as powder, from top to bottom."

3.—*The Effects of Tillage in Promoting Atmospheric Fertilization; and the Chemico-Absorptive Power of Soils.*

Treating of the fertilising effects of the atmosphere on soils, he thus expresses himself:—

"I think nothing can be said more strongly to confirm the truth of this, than what is related by the authors quoted by Mr. Evelyn; to this effect, viz.:—

"'Take of the most barren earth you can find, pulverise it well, and expose it abroad for a year, incessantly agitated, (that is, *stirred* often), it will become so fertile as to receive an exotic plant, from the furthest Indies; and to cause all vege-

tables to prosper in the most exalted degree, and to bear their fruit as kindly with us, as in their natural climates.'

"This artificial dust, he says, will entertain plants which refuse dung and other violent applications, and that it has a more nutritive power than any artificial dungs or compost whatsoever: and further, that by this toil of pulverising 'it is found that soil may be so strangely altered from its former nature, as to render the harsh and most uncivil clay obsequious to the husbandman, and to bring forth roots and plants, which otherwise require the lightest and hollowest mould.'"

To illustrate the great agricultural conception of atmospheric "manuring" embodied in these quotations, it will be necessary to go into some explanations,—based more especially on that most important chemical law of soils (usually termed their "absorbent power") which was discovered in 1845 by J. S. Thompson, Esq. (see Journal of the Royal Agricultural Society of England, vol. xi, p. 68), and was subsequently examined experimentally and commented on by Mr. J. Thomas Way, formerly consulting chemist to that body (ib. p. 313, and vol. xiii, p. 123).

Prior to the date of Mr. Thompson's discovery, the relation subsisting between the constituent matters of the atmosphere, and those of the soil on which it presses—stated very briefly—was held to be as follows: First, it had been long ascertained that oxygen, carbonic acid, and ammonia (all of them well determined constituents of the atmosphere), either when admitted by the opening effects of tillage into the interior of the soil in a gaseous condition, or when carried into it, as they constantly are, in solution with dew, rain, or melted snow, exercise not only a contributive fertilising function (analagous to that already assigned to stercoraceous manuring), but also an unequivocal decompositive action on the inorganic elements of the soil, which, as was thought, renders them soluble, and therefore fitted, by reason of such solubility, to be insumed as food by the roots of plants; these being, as was also conceived, unable physiologically to take in nutriments except in a state of fluidity. Again, secondly, it is important to have especially in view the process of reduction to a fluid state here spoken of, because in the then state of knowledge it involved an obvious inconsistency arising from this: that since we certainly know that a constant

descent of water is passing through all pervious soils, it is inconceivable how the dissolved substances should not be washed away from the roots growing in the upper stratum of mould, deep into the under drains or subsoil, by every successive rain fall.

To explain this seeming anomaly was one of the first fruits of Mr. Thompson's discovery, the history of which we shall now state. Led by a train of inductive reasoning (on which it is not necessary here to enter) to suspect the existence of a property in soils which had hitherto escaped observation, he sought its detection by a series of crucial experiments, which in a rough way may be instanced thus: He took some vegetable mould, and placing it in a filtering apparatus poured on it a quantity of water, holding in solution a salt of ammonia; and when enough had passed through by percolation into a receiving vessel beneath, the filtered liquid was next tested for ammonia: none, however, was found, and hence it became certain that, in the descent of the solution, the ammoniacal base had been abstracted from the water, and appropriated by the soil.

Now, seeing that long before this, a mechanical power of absorption had been discovered in soils,

analagous perhaps to that which is exhibited in the deodorizing effects of charcoal and other substances of extreme porosity, it might have been thought that the phenomenon exhibited by Mr. Thompson's experiment was due to some such physical property. But repeated trials ultimately shewed that the ammonia, in its disappearance from the liquid, had combined, chemically, in an insoluble, and hence unfiltrable, form, with some substance previously existing in the soil. What that substance was, Mr. Thompson did not determine ; and even yet its identity can hardly be said to be clearly made out.

Communicated to Professor Way, this most novel and striking addition to the chemical knowledge of soils was both confirmed and amplified by an extensive range of experiments conducted by that excellent chemist, and proving that besides the ammoniacal compounds used by Mr. Thompson, other substances belonging to the constituency of plant nutriment were subject to the same law of arrest when passing in aqueous percolation through the soil.

But, at present, it will be more convenient to limit the consideration of this phenomenon to that acknowledged relation which experiment has also

shewn soils to bear with compounds of ammonia, known to exist in a gaseous state in the atmosphere, and due to emanations from the putrescence and combustion of vegetable and animal substances constantly going on on the earth's surface. Of course, if no withdrawal of these unwholesome exhalations were provided for in nature, their accumulation in the atmosphere would speedily become malarious; but being, like that other constituent of the atmosphere—carbonic acid gas, highly absorbable by water in all its meteorological conditions of vapour, dew, rain, and snow, both are thus unceasingly withdrawn from deleterious accumulation in the air, and thrown to the earth and imbibed by the soil, there to play each its appropriate part in promoting fertility.

Now, keeping in view that, relatively speaking, the proportion of ammoniacal constituency in the air is extremely small; keeping, also, still more particularly in view, that ammonia is found, both by scientific experiment as well as practical husbandry, to be a very indispensable element in the growth of all vegetables, and in a more especial degree of the corn plants, it is impossible not to recognise, in Mr. Thompson's discovery of the chemico-absorbent power of soils, a blessed pro-

vision of nature for husbanding this most precious vegetative nutriment, by its conversion from solubility to insolubility at the very instant of its permeation through that upper stratum of the earth's surface in which the roots of plants most prevail. "The soil," says Liebig, expatiating on this subject in his work on Modern Agriculture, p. 30, "not only retains firmly all the food of plants which is actually in it, but its power to preserve all that may be useful to them, extends much farther. If rain or other water, holding in solution *ammonia*, *potash*, *phosphoric and silicic acids*, be brought in contact with the soil, these substances disappear almost immediately from the solution; the soil withdraws them from the water. Only such substances are *completely* withdrawn by the soil as are *indispensable* articles of food for plants; all others remain wholly or in part in solution." And in a preceding paragraph he had said, "the most continuous rain cannot remove from the field, except mechanically, any of the essential constituents of its fertility," p. 30.

But how, it will be asked, shall the roots (incapable, as they hitherto have been assumed to be, of taking in food in any other condition than that of liquidity) be able to receive this insoluble,

but indispensable, new compound. The reply, according to Liebig, is concise and simple, namely this,—that the belief hitherto entertained of land plants receiving their food dissolved in the capillary currents of moisture which supply their roots with water, "has been a great mistake;" and that now, in consequence of this discovery of the chemico-absorptive property of soils, "than which there is not to be found in chemistry a more wonderful phenomenon—one which more confounds human wisdom" (*Modern Agriculture*, p. 30), there is no conceivable method whereby terrestrial vegetation receives its radical sustenance except by virtue of some process of vital chemistry in the roots, in which the actual contact of their surfaces with the insoluble particles of aliment, minutely distributed in the soil, is indispensable. "There can be no doubt," says Liebig, "that, from the action just described of soil on potash, ammonia, and phosphoric acid, the majority of our cultivated plants cannot receive, out of a *solution* from the soil, their essential mineral constituents."—*Ib.* p. 37. Again: "It is more than probable that it is assigned to the majority of our cultivated plants to receive their nourishment directly from those portions of soil which

are in immediate contact with their rootlets."—*Ib.* p. 38. "From the action of soils already described, it follows, that plants must themselves play some peculiar part in the absorption of their food."—*Ib.* p. 42. "We frequently find in meadows, smooth lime stones, with their surfaces covered with a net work of small furrows. When these stones are newly taken out of the ground, we find that each furrow corresponds to a rootlet, which appears as if it had eaten into the stone."—*Ib.* p. 43.

Interpreted by the aid of these modern discoveries, we now know why Tull's tillage expedients for promoting the ramification and lengthening of the root fibres, as will be related in a succeeding chapter, were so successful in practice; because (as is appositely put in the way of illustration by Liebig,) "from a field which contains only half the quantity of food which is present in another, a plant with a double proportion of rootlet surface will receive as much nourishment as a plant with only half the rootlet surface obtains from the second field."—*Ib.* p. 71.

Now it is, that, aided by these discoveries, we can adequately appreciate Tull's philosophical accuracy in describing the available nutriment of plants as existing in the "superficies of the

pores, cavities, or interstices of the divided parts of the earth." Now it is, that modern agricultural science will humble itself before his prescience, when remembering his words, "that the mouths, or lacteals, being situate and opening in the convex superficies of roots, they TAKE their pabulum, BEING FINE PARTICLES OF EARTH, from the superficies of the pores, or cavities, wherein the roots are included." Again; "fibrous roots can take in no nourishment from any cavity unless they *come in contact with and press against* all the superficies of that cavity which includes them; for it dispenses the food to their lacteals by such pressure only."

Summing up his brilliant anticipations of the more minute, but not more comprehensive, discoveries and conclusions of subsequent agricultural philosophy, "it is certain," says Tull, "that earth is not divested or robbed of this pabulum, by any other means than by actual fire, or the *roots of plants.* For when no vegetables are suffered to grow in a soil, it will always grow richer. Plough it, harrow it, as often as you please; expose it to the sun in horse-paths all the summer, and to the frost of the winter; *let it be covered by water at the bottom of ponds or ditches;*

or if you grind dry earth to powder, the longer it is kept exposed, or treated by these or any other method possible (except actual burning by fire), instead of losing, it will gain the more fertility."

Nor were these observations and conclusions of Tull's mere barren acquisitions of knowledge; for, on the contrary, they formed the very basis of his practical doctrines on the primary importance of that perfect comminution and disintegration of the soil, which, says Professor Way, "however effected must render it more fertile, and place it in a position to benefit by the *manuring influences of the atmosphere and rain, which are probably much greater than we at all conceive.*" Written, as this passage was, with express reference to Tull's doctrines and practice, what follows from the same eminent agricultural chemist will not be thought inaptly cited here. "That he (Tull) had a conviction of the existence of some such power in the soil, [its absorptive property just described] *and of a manuring power in the air*, there can be no doubt; and since we have seen that a *worked* soil, although it contains perhaps only half its weight of clay, is yet more active as an absorbent than pure clay itself, we have further reason to believe in the wonderfully beneficial effect, which Tull

attributed to abundant stirring and trituration of the soil, by which continual exposure to atmospheric influences, its absorbent power is greatly augmented." *Roy. Agri. Jour. vol.* xi. *p.* 377.

But let us now endeavour to unfold the practical deductions afforded by these disquisitions.

First, then, it may be truly said of the fertilising constituents of the atmosphere, that though, generally speaking, they may, by adequate tillage, be procured in more or less abundance for any soil, yet it is necessary that, for that purpose, re-agents must exist in the staple, with which they may combine. "They are ready to enter into circulation, like a maiden to dance, but a partner is necessary" *(Modern Agriculture*, p. 28); and hence the unavoidable necessity arises, that, to soils destitute or deficient of these re-agents, their presence there must be acquired by the placing therein, artificially, of the absent constituents, or, in other words, *by the judicious exercise of special manuring* and thus again we find the axiom, "Tillage a substitute for Manure," must be content to suffer greater or less relaxation in practice.

Secondly. Experimental instances there cer-

tainly are, where Tullian husbandry has failed of success. In such cases the reasonable presumption is, that they were cases of soils deficient in the fixing re-agents; and if so, then not to use adventitious substitutes would be no less a violation of Tullian principles, than wastefully to apply them to soils where tillage alone would more profitably be adequate.

Thirdly. We conclude this branch by remarking that, step by step as we approach more nearly the culminating point of Tull's teaching, we shall find still increasing grounds for regarding them as emanations from a "deeply observant and philosophical mind" (Professor Way, in the Royal Agricultural Society's Journal, vol. xiii, p. 139), and as based on the soundest principles of natural knowledge.

§ II. OF HORSE-HOEING TILLAGE.

With regard more especially to inter-cultural tillage (*i. e.* both horse-hoeing and hand-hoeing), Tull thus expresses himself:—

"Hoeing is the breaking or dividing the soil by tillage, *whilst the corn or other plants are growing thereon.*

"Hoeing may be divided into deep (which is our horse-hoeing) and shallow, which is the English hand-hoeing; and also the shallow horse-hoeing, used in some places betwixt rows, where the intervals are very narrow, as sixteen or eighteen inches: this is but an imitation of the hand-hoe, or a *succedaneum* to it, and can neither supply the use of dung, nor of fallow, and may be properly called scratch-hoeing.

"It (horse-hoeing) differs from common tillage (which is always performed before the corn or plants are sown or planted) in the times of performing it; it is much more beneficial, and it is performed by different instruments.

"Land that is, before sowing, tilled never so much (though the more it is tilled the more it will produce) will have some weeds, and they will come in along with the crop for a share of the benefit of the tillage, greater or less, according to their number, and what species they are of."*

"But what is most to be regarded is, that as soon as the ploughman has done his work of

* It will, in the sequel be seen, that one of the specific advantages of horse-hoeing is the complete prevention of *weed*.

ploughing and harrowing, the soil begins to undo it, inclining towards, and endeavouring to regain its natural specific gravity; the broken parts by little and little coalesce, unite, and lose some of their surfaces, many of the pores or interstices close up during the seed's incubation, and hatching in the ground; and, as the plants grow up, they require an increase of food, proportionable to their increasing bulk; but on the contrary, instead thereof, that internal superficies, which is their artificial pasture, gradually decreases.

"The earth is so unjust to plants, her own offspring, as to shut up her stores in proportion to their wants; that is, to give them less nourishment when they have need of more: therefore, man, for whose use they are chiefly designed, ought to bring in his reasonable aid for their relief, and force open her magazines with the hoe, which will thence procure them, at all times, provisions in abundance, and also free them from intruders; I mean, their spurious kindred, the weeds, that robbed them of their too scanty allowance.

"There is no doubt, but that one-third part of nourishment raised by dung and tillage, given to plants or corn at many proper seasons, and apportioned to the different times of their exigen-

cies, will be of more benefit to a crop, than the whole applied as it commonly is, only at the time of sowing.

"Another extraordinary benefit of the new hoeing in husbandry is, that it keeps plants moist in dry weather, and this upon a double account.

"First, As they are better nourished by hoeing, they require less moisture, as appears by Dr. Woodward's experiment, that those plants which receive the greatest increase, having most terrestrial nourishment, carry off the least water in proportion to their augment; so barley or oats, being sown on a part of a ground very well divided by dung and tillage, will come up and grow vigorously without rain, when the same grains, sown at the same time, on the other part, not thus enriched, will scarce come up, or if they do, will not thrive until rain comes.

"Secondly, The hoe, I mean the horse-hoe (the other goes not deep enough), procures moisture to the roots from the dews, which fall most in dry weather; and those dews (by what Mr. Thomas Henshaw has observed) seem to be the richest present the atmosphere gives to the earth.

"As fine-hoed ground is not so long soaked by rain, so the dews never suffer it to become

perfectly dry; this appears by the plants, which flourish and grow fat in this, whilst those on the hard ground are starved, except such of them which stand near enough to the hoed earth, for the roots to borrow moisture and nourishment from it.

"And I have been informed by some persons, that they have often made the like observations; that, in the driest of weather, good hoeing procures moisture to roots, though the ignorant and incurious fancy it lets in the drought, and therefore are afraid to hoe their plants at such times, when, unless they water them, they are spoiled for want of it.

"These experiments will show how it is in our own power to make *solstitia* become, in some measure, *humida*, instead of wishing them so;* and also proves the Virgilian theory in this verse, viz., *Hic sterilem exiguus ne deserat humor arenam*, to be (as almost all the first Georgic is) directly contrary to truth.

* Humida solstitia atque hyemes orate serenas
Agricolæ:——

The solstice moist, serene the winter sky,
For this, ye swains, intreat the powers on high.

"But to hoe with advantage against dry weather, the ground must have been well tilled or hoed before, that the hoe may go deep, else the dews, that fall in the night, will be exhaled back in the heat of the day."

CHAPTER VII.—THEORY OF TILLAGE, CONTINUED.

Definitions Respecting the Cause of Different Degrees of Fertility in Soils at Different Times. Of the Pores of Soils. Their Specific Office. The "Pasture" of Plants. The Meaning of that Term Explained. The Nutritive Agents concerned in Vegetation. The Soil. Water. Air. Tull's Conceptions respecting Atmospheric "Nitre." The Functions of the Soil Relatively to the Atmosphere. Want of Air one of the Causes of Blight and Lodging in Corn. Heat and Light. Want of Light also a Cause of Blight and Lodging in overcrowded Crops.

Amongst the propositions more anxiously stated and argued by Tull, was the following: That the different productiveness at different times of one and the same soil, depended on the greater or less aggregate extent of the interstitial surfaces of its pulverised fragments, when made fine by the action of tillage or dung, and the loosening effects of atmospheric agency. These interstitial surfaces he called the pasture of plants, in the same sense as the superficies of a grass field is the pasture of cattle. He believed that on them only could the nutritive substances which formed the plants' food be given out by the soil, analogously to the growth of herbage on the surface of a field; and he insisted, that without interstitial passages the

fine root fibres could not penetrate in search of the aliment there eliminated.

"This pasture," he writes, "I shall endeavour to describe.

"It is the inner (or internal) superficies of the earth; or, which is the same thing, it is the superficies of the pores, cavities, or interstices of the divided parts of the earth, which are of two sorts, viz. *natural* and *artificial*."

Into his definitions of the *natural* pasture it is unnecessary to go; but, he says, the "*artificial* pasture may be increased in proportion to the division of the parts of earth.

"A cube of earth of one foot has but six feet of superficies. Divide this cube into cubical inches, and then its superficies will be increased twelve times, viz. to seventy-two superficial feet. Divide these again in like manner and proportion; that is, divide them into parts that bear the same proportion to the inches, as the inches do to the foot; and then the same earth, which had at first no more than six superficial feet, will have eight hundred sixty-four superficial feet of artificial pasture; and so is the soil divisible, and this pasture increasible, *ad infinitum*.

"Poor land does not afford an internal super-

ficies so well stocked with these fruitful particles, as rich land does, but this we may compensate by *dividing* it more; to the end that what this artificial pasture wants in quality, may, by division, be made up in quantity.

"The common methods of dividing the soil are these, viz. by *dung*, by *tillage*, or by both; for *Vis unita fortior.*"

Having, thus, had described the the manner in which the "fruitful particles" of the soil are eliminated, as well as made accessible to the roots of plants, by an easy transition, we may now enter on an examination of Tull's conceptions, regarding the Food of plants, whether received from the *soil* or the *air:* and, on this subject, he thus writes:—

"The chief art of a husbandman is to feed plants to the best advantage; but how shall he do that, unless he knows what is their food? By food is meant that matter which, being added and united to the first stamina of plants, or plantulæ, which were made in little at the creation, gives them, or rather is their increase.

"It is agreed that all the following materials contribute in some manner to the increase of

plants, but it is disputed which of them is that very increase or food: 1, nitre; 2, water; 3, air; 4, fire (*i. e.* heat); 5, earth:" and although *light* does not appear in this enumeration, its agency in vegetation, we shall presently find, was by no means overlooked by him.

Thus, then, the several agents in vegetation here cited by Tull may be resolved into three classes: 1, Terrestrial; 2, Atmospheric; 3, Climatal.

§ 1, TERRESTRIAL AGENTS IN VEGETATION.

That Tull conceived the chief part of the bulk of plants to be composed of substances contributed by the soil, is undeniable; and thus, in so far as modern discovery has shewn that the carbonic acid gas of the atmosphere is really the chief quantitative source, he was in error. But entertaining, as he did, a full conviction that plants obtain an important, although, as he thought, not the chief part of their sustenance from the air, we shall afterwards see, that this defect in his physiological knowledge in nowise led him to underrate the necessity of so conducting his tillage reformations as to procure for his crops a maximum amount of aerial nutriment.

Reverting now to his own question, What substance in nature is that which is the "very increase or food of plants?" he thus answers it:

"That which nourishes and augments a plant is the true food of it.

"Every plant is EARTH, and the growth and true increase of a plant is the addition of more earth. When this additional earth is assimilated to the plant, it becomes an absolute part of it.

"And earth is so surely the food of all plants, that with the proper share of the other elements, which each species of plants requires, I do not find but that any common earth will nourish any plant. The only difference of soil (except the richness) seems to be the different heat and moisture it has; for if those be rightly adjusted, any soil will nourish any sort of plant."

Next, as respects that other terrestrial vegetative agent, namely, WATER, derived from the atmosphere, but existing as moisture in the soil, Tull assigned to it no substantive alimentary quality.* Thus, he says, "Water, from Van Hel-

* It is undeniable that Tull was ignorant of the physiological fact that water, (both as water and as contributing its elements of oxygen and hydrogen,) is a substantive and indispensable nutriment in the formation of all the parts of

mont's experiment, was by some great philosophers thought to be it" (that is, the very food of plants); "but these were deceived in not observing that water has always in its intervals a charge of earth from which no art can free it." Hence, then, we see that Tull regarded water as a mere instrument in the process of nutrition, his belief being that "A plant cannot separate the pabulum of plants from the parts to which they adhere without the assistance of water, which helps to loosen them."*

Thus impressed with the important office performed by a proper amount of moisture in the soil, he was no less conscious of the evil effects of supersaturation. Himself farming on a porous substratum of chalk, his experience appears to have embraced no operations of under-draining;

plants; but this led to no defect in his system, because the same processess of tillage devised by him to procure to the soil that degree of moisture requisite to loosen the solid pabulum, also introduced an equally well regulated supply of aqueous aliment.

* "Water alone withdraws from the soil none of these substances (phosphoric acid, potash, and ammonia); their passing into the organism of plants must, therefore, be directly effected by the organs of absorbtion in the ground, (*i. e.* the roots,) *with the co-operation of water.*" *Modern Agriculture, p.* 107.

and hence there is no mention, direct or incidental, of drainage in his work. Yet he beautifully typified its wonderful effects on vegetation in the following illustration :—

"Let thyme and rushes change places, and both will die; but let them change their soil, by removing the earth wherein the thyme grew, from the dry hill down into the watery bottom, and plant rushes therein; and carry the moist earth, wherein the rushes grew, up to the hill; and there thyme will grow in the earth that was taken from the rushes; and so will the rushes grow in the earth that was taken from the thyme: so that it is only more or less water that makes the same earth fit either for the growth of thyme or rushes."

Of that pernicious soddenness of the soil arising from imperfect management, he was well aware; and accordingly, he thus writes :—

"Although hard ground, when thoroughly soaked with rain, will continue wet longer than fine tilled land adjoining to it; yet this water serves rather to chill than nourish the plants standing therein, and to keep out the other benefits of the atmosphere, leaving the ground still harder when it is thence exhaled; and being at last once become dry, it can admit no more

moisture, unless from a long-continued deluge of rain, which seldom falls till winter, which is not the season for vegetation."

§ 2. ATMOSPHERIC AGENTS IN VEGETATION.

To the AIR of the Atmosphere he attributed both Physical and Physiological qualities. First: *physically* he regarded it as a mechanical medium in which particles of earth (in the chemical sense) and effluvia float about, which, though nutritious in their nature, and necessary to vegetation, were nevertheless, he thought, too small in quantity "to augment vegetables to that bulk they arrive at," believing, as we have seen, that the constituents of the soil contributed most to the mere bulk of plants. But, whatever might be the real amount of these atmospheric nutriments, he truly believed the foliage as well as the roots to be capable of imbibing and assimilating them; and amongst their number he specially enumerates *nitre*, assigning to it the property both of promoting, when conveyed by dews and rain into the soil, that really chemical reaction which he termed "pulverisation," and of contributing actual food in the process of vegetation (see quotation, p. 83). That in this, Tull had anticipated the conclusions of the

nitrogenous theory in the vegetable physiology of the present day, could not justly be claimed for him; but, at least, it is no less a surprising than an important circumstance to find (as afterwards we shall) a high authority in the modern controversy, citing Tull's method of tillage as eminently calculated to promote nitrogenous fertilization in vegetable culture. *Physiologically*, Tull held that the chief office of the air of the atmosphere was "to purify the sap by the leaves, as the blood of animals is depurated by their lungs." Now, in so far as modern Vegetable Physiology teaches, that between the oxygen of the atmosphere and the tissues and sap of plants, a certain reaction of vital chemistry takes place, resulting, as in animal respiration, in the formation and ejection of carbonic acid gas, Tull's proposition, just quoted, may be deemed essentially correct. True it is that Tull was ignorant (for the fact was unknown to science at that time) that another chief office of the air of the atmosphere, is to furnish, through its carbonic acid, what constitutes by far the greatest constituent of plants, namely, *Carbon*.*

* Yet the following remarkable passage, in his chapter on the Food of Plants, shews that his habits of inductive observation and reasoning had led him to the verge of dis-

But, practically, this deficiency in the scientific knowledge of that day, occasioned no imperfection in Tull's system, because the same methods of culture designed by him, to give free access to the oxygenous, ammoniacal, and aqueous alimentary components of the atmosphere, equally promoted the abundant accession of its carbonaceous nutriment.

As a very instructive instance of the manner on which Tull was constantly bringing his comprehensive and fundamentally accurate knowledge in natural science to bear on actual practice, the following quotation from his chapter on "Blight," (based as the instance partly is on an atmospheric phenomenon) may here be given :—

"The most effectual remedy against the Blight is that which removes all its causes, as—First: Want of Nourishment.—The horse-hoe will, in wide intervals, give wheat throughout all the stages of its life as much nourishment as the discreet hoer pleases. Secondly: WANT OF AIR.—

covering that carbon is the chief basis of vegetative nutriment. "Indeed," he says, "the true food of plants may be also the *fuel of fire*, which is so greedy of that food (*i, e.* vegetable matter) as to carry it all away that comes within reach of the flame."

Air, being a fluid, moves most freely in a right or straight line, for there the fewest of its parts meet with any resistance; as a straight river runs swifter than a crooked one, from an equal declivity; because more of the water strikes against the banks at the turnings, and is there somewhat retarded; and the rest moving no faster than in the straight river, the whole stream of the crooked must be slower in its course than that of the straight river.

"The air cannot pass through sown corn" (*i. e.* sown broadcast, in contradistinction to drilled corn) "in a direct line, because it must strike against and go round every plant, they standing all in the way of its course, which must stop its current near the earth; and the air amongst sown corn is like water amongst reeds or osiers in the side of a river, it is so stopped in its course, that it almost becomes an eddy; and since air is about eight hundred times lighter than water, we may suppose its current through the corn is more easily retarded, especially near the earth, where the corn has occasion for the greatest quantity of air to pass; for though the upper part of the wheat be not able to stop a slow current of air, yet it does so much raise (*i. e.* deflect upwards) even a swift one, as to throw it off from the ground,

and hinder it from reaching the lower parts of the stalks, where the air must therefore remain, in a manner, stagnant; and the thicker the wheat is, where it stands promiscuously, the less change of air can it have; though the greater the number of the stalks is, the more fresh air they must require.

"But the confused manner in which the plants of sown wheat stand, is such, that they must all oppose the free entrance of air amongst them, from whatever point of the compass it comes.

"Now, it is quite otherwise with wheat drilled regularly with wide intervals, for therein the current of air may pass freely (like water in a straight river where there is no resistance), and communicate its nitre to the lower as well as upper leaves, and carry off the recrements they emit, not suffering the plants to be weakened, as an animal is, when his lungs are forced to take back their own expirations, if debarred from a sufficient supply of fresh, untainted air. And this benefit of fresh air is plentifully and pretty equally distributed to every row in a field of hoed wheat."

§ 3. CLIMATIC AGENTS IN VEGETATION.

Heat and Light.—In commenting on the phenomenon of blight in corn, Tull assigned three

causes for its occurrence: 1st, want of nourishment; 2nd, want of air (both already noticed); and the 3rd, "WANT OF THE SUN'S RAYS." On this point he thus remarks:—

"Sown wheat plants, by their irregular position, may be said to stand in one another's LIGHT for want of which they are apt to fall.

"It is true, the whole field of plants receive the same quantity of sun-beams amongst them, whether they stand confusedly or in order; but there is a vast difference in the distribution of them, for none, or the very least share of beams, is obtained by those parts which need the greatest share, in the confused plants. And when the crural parts, that should support the whole body of every plant, are deprived of their due share of what is so necessary to strengthen them, the plants (like animals in the same case) are unable to stand.

"But in drilled wheat, where the plants stand in a regular order, the sun-beams are more duly distributed to all parts of the plants in the ranks; for which way soever the rows are directed, if they be straight, the rays must, sometime of the day, fall on the intervals, and be reflected by the ground, whence the lower parts of the wheat

stalks must receive the greater share of HEAT, being nearest to the point of incidence, having no weeds to shadow them."

Now, while it is true that modern discovery has indeed both amplified some of Tull's generalisations on the terrestrial, atmospheric, and climatal agencies in vegetation, and modified others, it is impossible to allege, that hitherto it has imported into agricultural science any fresh knowledge which lessens the validity of his propositions as bases on which he constructed his reformed practice; while, again, the reader will, farther on, find this comprehensive genius fashioning expedients of actual farming, evidently on the bold and well founded conception that the atmosphere and its various constituents, nay even the very HEAT and LIGHT of the sun were parts and pertinents of the freehold; and, as such, no less claiming the reasoning husbandman's regard in his methods of tillage, than the soil itself.

CHAPTER VIII.—THEORY OF TILLAGE, CONTINUED.

§ 1, Of the Roots of Corn Plants. Their Instincts in Search of Food.—Their Function of Subdivision. This increased by Mechanical Severance Analagous to Pruning. Liebig cited, § 2, Of the Tillering of Corn Plants. This Function of primary importance in Tullian Husbandry. Thin Sowing Augments it.—Quantity of Seed per Acre Sown by Tull. Principles which guided him in Sowing.—Usual number of Stalks to a Single Seed in Broadcast Sowing.—Great increase of these in his Method. § 3, Of Nourishing the Plant by Tillage during its Growth. Great proportion of Plants which Die Out in Ordinary Culture. § 4, Of the Progressive Amelioration of the Soil produced by Horse Hoeing Tillage.—The Reasons Explained. Horse Hoed Corn less Exhaustive than Sown Corn. The proportion of Grain greater, and of Straw less, in Horse Hoed Corn than Broadcast. Six Successive Crops without Dung or Fallow instanced in Confimation of this.—Nothing added to the Soil in these instances except what Evelyn calls the "Celestial Influences."

§ I, OF THE ROOTS OF CORN PLANTS.

"ALL roots," he says, "have branchings and fibres going all manner of ways, ready to fill the earth that is open,—meaning thereby that the spreading of radical filaments in search of food, and hence the quantity of food obtained by them, in a fertile soil, is in proportion to that openness of texture which thorough tillage accomplishes. These fine threads, he truly held, even in annual plants, such as corn, radiate several feet distant from the central root.

Another property he correctly assigned to these rootlets is, that not only do they naturally, in their uncultivated growth, undergo a process of ramification so as to search out every cranny from whence nutriment may be drawn, but, if mechanically severed, they much more multiply in a manner analagous to the vast number of shoots which issue from the stump of a lopped branch.

"It is true," says Tull, "that in the last hoeings, even in the middle of a large interval, many of the roots may be broken off by the hoe-plough, at some considerable distance from the bodies; but yet this is no damage, for they send out a greater number of roots." "And these new, young, multiplied roots are fuller of lacteal mouths than the older ones, which makes it no wonder that plants should thrive faster by having some of their roots broken off by the hoe;" for as (the first produced) roots do not enter every pore of the earth, but miss great part of the pasture, which is left unexhausted, so when new roots strike out from the broken parts of the old, they meet with that pasture which their predecessors missed, besides that new pasture which the hoe raises for them; and those roots which the hoe pulls out without breaking and covers again, are

turned into a fresh pasture; some broken and some unbroken, altogether invigorate the plants. Moreover, *in hoeing a plant, the additional nourishment thereby given enables it to send out innumerable additional fibres and roots, which fully demonstrates, that a plant increaseth its mouths, in some proportion, to the increase of food given to it; so that hoeing, by the new pasture it raises, furnishes both food and mouths to plants; and it is for want of hoeing that so few are brought to their full growth and perfection.*

Such the physiological facts in relation to the properties of roots recorded by a practical husbandman, teaching a reformed practice of husbandry in the first half of the 17th century; and now the inductions of a leading philosopher of the latter part of the 19th, addressing himself to the modern agriculturist: "An accumulation of nourishment in the upper layer of the field enables plants, during the first period of their developement, *to send out ten-fold, perhaps a hundred-fold, more absorbing rootlets*, than they otherwise would have done; *and their later growth will be in proportion to the greater number of rootlets thus gained*, by which they are enabled to seek and appropriate the food distributed sparingly throughout the

deeper layers."—*Liebig, on Modern Agriculture*, p. 72.

§ II. OF THE TILLERING OF CORN PLANTS, AND THIN SOWING.

1. *Of Tillering.*

"To tiller is to branch out into many stalks, and is the country word that signifies the same with *fructicare*.

Tull attached very primary importance to that phenomenon termed tillering or stooling, which belongs to the corn plants, in common with the other grasses. Destitute of a true stem, the corn grasses (of which only we shall here speak) generate their buds in contact with the roots, sending their branches (which is the real nature of the straw) vertically upwards into the air, and not horizontally as in most vegetables. Now, in the process of tillering he observed, that the number of buds, and hence, consequently, the number of ear bearing stalks which issue from the seedling, was greater or less,—first, in proportion to the fertility of the soil, whether that fertility was created by tillage and manure, or more tillage and less manure, or much tillage and

no manure;—and secondly, in proportion to the freedom from overcrowding, attainable by a sparing use of seed.

2. *Of Thin Sowing.*

It will be instructive to quote some of his precepts on this important subject of thin sowing, of which, as of every other chief improvement of modern agriculture, he is the undisputed, though forgotten author.

"Six gallons of middle-sized seed we most commonly drill on an acre; yet on rich land planted early, four gallons may suffice; because then the wheat will have roots at the top of the ground before winter, and tiller very much, without danger of the worms, and other accidents that late-planted wheat is liable to.

"If it is drilled too thick, it will be in danger of falling; if too thin, it may happen to tiller so late in the spring, that some of the ears may be blighted, yet a little thicker or thinner does not matter.

"A too great number of plants do neither tiller, nor produce so large ears, nor make half so good a crop, as a bare competent number of plants will.

"When wheat is planted early, less seed is required, than when late; because less of it will die in the winter, than of that planted late, and it has more time to tiller.

"Poor land should have more seed than rich land, because a less number of the plants will survive the winter on poor land.

"The least quantity of seed may suffice for rich land that is planted early; for thereon very few plants will die: and the hoe will cause a small number of plants to send out a vast number of stalks, which will have large ears, and in these, more than in the number of plants, consists the goodness of a crop.

"Another thing must be considered, in order to find the just proportion of seed to plant; and that is, that some wheat has its grains twice as big as other wheat of the same sort, and then a bushel will contain but half the number of grains: and one bushel of small-grained wheat will plant as much ground as two bushels of the large-grained; for, in truth, it is not the measure of the seed, but the number of the grains, to which respect ought to be had in apportioning the quantity of it to the land.

"Some have thought, that a large grain of

wheat would produce a larger plant than a small grain, but I have full experience to the contrary. The small grain, indeed, sends up its first single blade in proportion to its own bulk; but afterwards becomes as large a plant as the largest grain can produce, *cæteris paribus*.

"Farmers in general know this, and choose the thinnest smallest grained wheat for seed; and therefore prefer that which is blighted and lodged, and that which grows on new-broke ground, and is not fit for bread, not only because this thin wheat has more grains in a bushel; but also because such seed is least liable to produce a smutty crop, and yet brings grains as large as any.

"I myself had as full proofs of this as can possibly be made in both respects.

"It was from such small seeds that my drilled Lammas-wheat produced the ears of that monstrous length* described in this chapter. I never saw the like, except in that one year; and the grains were large also.

"And as full proofs have I seen of thin seed wheat escaping the smut, when plump large-grained seed of the same sort have been smutty.

* See § iii, of this chapter.

"As to the *depth*, we may plant from half an inch to three inches deep. If planted too deep, there is more danger of its being eaten off by worms, betwixt the grain and the blade; for as that thread is the thread of life during the winter (if not planted early), so the longer the thread is, the more danger there will be of the worms.

"A wheat-plant, that is not planted early, sends out no root above the grain before the spring; and is nourished all the winter by a single thread, proceeding from the grain up to the surface of the ground."

But to revert to the phenomenon of tillering, on which he so greatly relied. Having, as we have seen, fertilised his soil by *tillage*, and promoted the permeation of the roots by *pulverisation*—having by these means, as well as by *actual severance*, multiplied the roots, and thereby increased their absorbent surface; having also, by *drilling* and *thin seeding*, secured to the growing plant the freest accession of *air*, *heat*, and *light;* need we be surprised to find Tull thus writing:—"we augment our wheat crops by increasing" (*i. e.* causing to tiller) "the number of

stalks, from one, two or three, to thirty or forty, in ordinary field land."*

"The same plant that, when poor, sends out but two or three tillers, would, if well nourished by the hoe or otherwise, send up a multitude of tillers, as is seen in hoed wheat and sown wheat.

"But though a too great number of plants be upon many accounts very injurious, yet it is best to have a competent number, which yet needs not be so exact but that we may expect a great crop from twenty, forty, or fifty plants in a yard of the treble row, if well managed."

§ III. OF NOURISHING THE PLANT BY TILLAGE DURING ITS GROWTH.

But Tull also taught that, to induce mere tillering was not enough, unless each stalk and each ear so produced, should be assiduously nurtured during its growth into full perfection; and such, accordingly, was the design of his horse-hoeing husbandry, by which the benefits

* The Rev. Mr. Smith, describing the success of his Tullian experiment, says, there is scarcely a plant but tillers twenty, thirty, or forty stalks to a grain. "*A Word in Season*," *15th Edition, p.* 16.

of frequent interculture should be imparted to the growing corn up to the time of its shedding the bloom. Beyond this period he found it inexpedient to prolong the operation.

"By this means," says he, "We augment our wheat crops four ways; not in number of plants, but in stalks, ears, and grains.

"The *first* is by increasing the number of stalks from one, two, or three, to thirty or forty to a plant, in ordinary field land.

"We augment the crop, by bringing up all the stalks into ears, which is the *second* way; for if it be diligently observed, we shall find that not half the stalks of sown wheat come into ear.

"If a square yard of sown wheat be marked out, and the stalks thereon numbered in the spring, it will be found that nine parts in ten are missing at harvest.*

"I saw an experiment of this in rows of wheat that were equally poor, one of these rows was increased so much, as to produce more grains than ten of the other, by bringing up more of its stalks into ears, and also by augmenting its ears

* See "*Stevens' Book of the Farm*," § 2393, for some very striking particulars connected with this subject.

to a much greater bigness, which is the *third* way; for it is pretty plain that the ears are formed together with the stalks, and will be very large or very small, in proportion to the nourishment given them; like as the vines, if well nourished, bring large bunches of grapes; but if ill nourished, they produce few bunches, and those small ones; and many claspers are formed, which would have been bunches, if they had had sufficient nourishment given them at the proper time.

"The last and *fourth* way of augmenting the produce of wheat plants, is by causing them to have large and plump grains in the ears; and this can no way be so effectually done, as by late hoeing, especially just after the wheat is gone out of the blossom, and when such hoed grains weigh double the weight of the same number of unhoed (which they frequently will), though the number of grains in the hoed are equal, yet the hoed crop must be double.

"Thus by increasing the number of stalks, bringing more of them up into ear, making the ears larger, and the grain plumper and fuller of flour, the hoeing method makes a greater crop from a tenth part of the plants, than the sowing method can. The fact of this nobody can doubt

who has observed the different products of strong and of weak plants, how the one exceeds the other.

"In a large ground of wheat it was proved, that the widest hoed intervals brought the greatest crop of all: dung without hoeing, did not equal hoeing without dung. And what was most remarkable, amongst twelve differences of wider and narrower spaces, more and less hoed, dunged and undunged, the hand-sowed was considerably the worst of all; though all the winter, and the beginning of the spring, that made infinitely the most promising appearance; but at harvest yielded but about one-fifth part of wheat of that which was most hoed, there was some of the most hoed, which yielded eighteen ounces of clean wheat in a yard in length of a double row, the intervals being thirty inches and the partition six inches.

"The same harvest, a yard in length of a double row of barley, having six inches partition, produced eight hundred and eighty ears in a garden; but the grains happened to be eaten by poultry before it was ripe, so that their produce of grains could not be known. One like yard of a

hoed row of wheat in an undunged field, produced four hundred ears of Lammas wheat.

"I have numbered one hundred and nine grains in one ear of my hoed cone wheat of the grey sort; and one ear of my hoed Lammas wheat has been measured to be eight inches long, which is double those of sown wheat; indeed, it is not every year they grow to that length, and it is always where the plants are pretty single; but there is no year wherein one ear of my hoed does not weigh more than two of the sown ears, taking a whole sheaf of each together, without choosing."

§ IV. OF THE PROGRESSIVE AMELIORATION OF THE SOIL, PRODUCED BY HORSE-HOE CULTURE.

Tull found that, without the use of any manures, his method of corn tillage was such as to maintain his land in full heart, notwithstanding unintermittent wheat growing (for ultimately, he raised neither barley or oats); nay, more, he had the unequivocal testimony of progressively more abundant crops to convince himself and others, that he was actually ameliorating the staple. His neighbours, he writes, "allow that my farm is one-third better for a tenant than when I took it in hand;" and the world attested his

success by flocking to witness his practice, and by importuning him to promulgate, through the press, the means by which that success had been attained. Even his detractors (stirred up by the booksellers, whom he had enraged by publishing his work on his own account), bore evidence to the same fact, by falsely attributing the notorious abundance of his harvests to a rich soil.

Explanatory of the increasing fertility of his land under this management, he writes,—"The plants of sown corn being treble in number to those of the drilled, and of equal strength and bulk, whilst they are very young, must exhaust the earth whilst it is open, thrice as much as the drilled plants do; and before the sown plants grow large, the pores of the earth are shut against them, and against the benefit of the atmosphere; but for the drilled, the hoe gives constant admission to that benefit; and if the hoe procures them, (by dividing the earth) four times the pasture of the sown, during their lives, and the roots devour but one half of that, then, though the hoed crop should be double to the sown, yet it might leave twice as much pabulum for a succeeding crop. It is impossible to bring these calculations to mathematical rules, but this is certain in practice, that

a sown crop, succeeding a large undunged hoed crop, is much better than a sown crop, that succeeds a small dunged sown crop. And I have the experience of poor, worn-out heath-ground, that, having produced four successive good hoed crops of potatoes (the last still best), is become tolerable good ground.

"To the reasons already given there is another to be added, why horse-hoed wheat exhausts the soil less than sown crops, where the product of wheat produced by each is equal; which reason is, that the former has much less straw than the latter; as appears by the different quantities of grain that a sheaf of each, of equal diameter, yields; one of the former yielding generally double to one of the latter; for a sheaf of the sown has not only more small under ears, but also its best ears bear a less proportion to their straw than the other; for a straw of sown wheat six feet high, I have found to have an ear but of half the size of an ear of drilled wheat on a stalk five feet high, having measured both of them standing in the field, and rubbed out the grain of them. This difference I impute to the different supply of nourishment at the time when the ears are forming.

"Thus the sown crop exhausts a soil much more by its greater quantity of straw.

"And this is one reason why annual crops of sown wheat cannot succeed as crops of horse-hoed wheat do. There must be dung and fallow to repair the exhaustion of the sown; neither of which are necessary for crops of the horse-hoed.

"A field that is a sort of a heath-ground, used to bring such poor crops of corn, that heretofore the parson carried away a whole crop of oats from it, believing it had been only his tithe. The best management that ever they did or could bestow upon it, was to let it rest two or three years, and then fallow and dung it, and sow it with wheat, next to that with barley and clover, and then let it rest again; but I cannot hear of any good crop that it ever produced by this or any other of their methods; it was still reckoned so poor, that nobody cared to rent it. They said dung and labour were thrown away upon it: then immediately after two sown crops of black oats had been taken off it, the last of which was scarce worth the mowing, it was put into the hoeing management, and when three hoed crops had been taken from it, it was sown with barley, and brought a very good crop, much better than ever it was known to

yield before; and then a good crop of hoed wheat succeeded the barley; and then it was again sown with barley, upon the wheat stubble; and that also was better than the barley it used to produce.

"Now, all the farmers of the neighbourhood affirm, that it is impossible but that this must be very rich ground, because they have seen it produce six crops in six years, without dung or fallow, and never one of them fail! But, alas, this different reputation they give to the land, does not at all belong to it, but to the different sorts of husbandry; for the nature of it cannot be altered but by that, the crops being all carried off it, and nothing added to supply the substance those crops take from it, except (what Mr. Evelyn calls) the CELESTIAL INFLUENCES, and that these are received by the earth, in proportion to the degrees of its PULVERISATION."

CHAPTER IX.—AN EPITOME OF TULL'S DIRECTIONS FOR THE PRACTICE OF HIS SYSTEM OF TILLAGE.

§ 1, Of Changing the Fields from the Old to the New Method.—§ 2, Of Sowing.—§ 3, Of Horse Hoeing.—§ 4, Of Hand Hoeing. § 5, Of Reaping.—§ 6, Of Ploughing the Stubbles, and preparing the ground for the next crop.—The Great Operative Economy of Tullian Husbandry.

HITHERTO we have been engaged in preliminary, though very important matter, preparatory to now entering on a description of TULL'S actual practice of husbandry, divisible into—

§ 1. The Means by which he progressively changed the culture of his fields from the Old to his own New husbandry.

§ 2. The Sowing and relative processes.

§ 3. The Intercultural processes of Horse-hoeing.

§ 4. The Hand-hoeing operations.

§ 5. The Reaping.

§ 6. The Preparing of the Stubbles for the next crop.

§ 1. *The transitionary processes from the Old to the New Husbandry.*

In describing his manner of subdividing the fields into Tullian ridges, Tull takes, by way of

examplar, an acre, of the dimensions of sixty-six feet (a chain length) broad, and six hundred and sixty feet (ten chain lengths) long.

Always making the change succeed a bare fallow, he, at the proper season, formed narrow ridges, at the rate, during the first part of his experience, of eleven to the acre's breadth (hence six feet each), and latterly, of fourteen to the acre, giving, in that case, four feet eight inches per ridge, as near as may be. Allowing a width of nine inches to each fur the broader ridge consequently contained eight such furs, and the narrower, six.

For reasons which will afterwards be stated, a greater or less degree of *gathering* was practised, so as always to leave a parting fur or balk, eighteen inches wide at bottom, and completely bared of soil, by turning a plough slice, the full depth of the staple, towards each of the adjoining ridges.

In this manner, assuming a six-feet ridge to consist, when first marked out, of eight furs, and the narrower one, of six, the staple of the ridges by the accession of the mould gathered from the balks was increased one-fourth in the former, and one-third in the latter. Such was

the simple method by which, field after field, Tull started in his new practice.

§ 2. *The Sowing and its relative processes.*

And here the more characteristic details of Tull's system commenced; for in place of seeding the entire breadth of the ridges—along its central line, only, did the drill machine pass,—depositing from one to four equi-distant rows, according as experience led him, from year to year, to vary the number; and thus each set of rows was flanked, right and left, by an unseeded space, bounded exteriorly by the bared balk. By constructing a double-bodied drill machine, and coupling two small harrows by a wide cross-bar, he was enabled both to sow and to harrow two ridges at a time; the animal drawing either implement, walking midway in the parting fur, or bared balk.

Let us next anticipate, very briefly, the offices assigned to the unseeded spaces on either side the rows.

First. By virtue of spring and summer horse-hoe workings in these, conjointly with hand-hoeing in the rows, the extermination of every kind of

foul vegetation was attained. Secondly: The soil composing them, became, by means of that continuous tillage, a highly fertilized source, from which, in addition to the sustenance yielded by the mould of the rows, the growing plants were able to draw more and more nutrition, the more and more their increasing bulk demanded it. And, thirdly, these uncropped spaces ultimately became, by that operation of the plough termed *feering*, the seed beds, (accumulated in the bared balks), of the next ensuing crop.

And here, again, the value of Tull's discoveries in the physiology of roots is strikingly evinced, since he conclusively determined that those of the central rows not only radiated wide into the lateral fallows, but had their function to collect nutriment, as well as that nutriment itself increased by the summer stirrings.

Still, however, in like manner as any given space of pasture ground can only maintain a limited number of beasts, so a certain area of tilled soil can rear a certain number, only, of corn plants; and a chief part of Tull's early experimental practice, was, to find out what stock of plants his own soil was competent to feed. But he neither expected to discover, nor did discover,

any general formula on this point; concluding truly, that the ratio must be as variable as the variety of soils in point both of fertility and climatal circumstances. Nevertheless, the methods by which he guaged, so to speak, the amount of cereal productiveness into which, by horse-hoeing tillage, the staple of his own farm could yearly be stimulated, are of universal application.

Thus, experimenting, first with double rows, in each ridge, he abandoned that number for a time, and tried quadruple and triple drills on ridges slightly gathered; but the plants in the inner rows, developing themselves less completely than the exterior ones, he hence concluded, that therein was exhibited clear evidence of imperfect arrangement; and, in subsequent trials, he still more heaped the ridges, insomuch, that in proportion as the inner rows were more and more removed from the nutriment in the fallow spaces, each had a deeper and deeper soil to root in. Complete equality of growth was now the result; but, on the other hand, he likewise found, that too much mould had thereby been withdrawn from the fallow spaces. For years, however, he persevered with three rows, for several reasons.

One of these shall be mentioned afterwards, p. 113. Another " was, that when part of a row was trodden out by hunters, or torn out by any accident, there might remain two rows entire, for when such accidents should happen to a double row, one only remaining in such places, might be too little between wide intervals;" while, a third reason, " was the alloy the middle row makes to the too great luxuriousness of the other two rows." Writing, however, at a subsequent period of his experience, he thus observes, " I now choose to have fourteen ridges to an acre, four feet eight inches each, and one only partition of ten inches in each of them," (*i.e.*, two rows, ten inches apart in each ridge.)

" This, I find, answers all the ends I propose. If the partitions are narrower, there is not sufficient room in them for the hand-hoe to do its work effectually; if wider, too much earth will (by being withdrawn from the fallow spaces) lose the benefit of the horse-hoe. If I am taxed with levity in changing my treble rows for double ones, it will not appear to be done of a sudden, for, in my first directions, I advised double rows where hand-hoeing was likely to be necessary. I also advised the trial of both sorts. And, now, upon fuller

experience, I find the double rows much preferable to the treble, especially for wheat.

"By all these three methods I have had very good crops; but as this I now describe is the latest, and is (as it ought to be) the best, I publish it as such, without partiality to my own opinions; for I think it less dishonourable to expose my errors, when I chance to detect them, than to conceal them; and, as I aim at nothing but the truth, I cannot, with any satisfaction to myself, suffer anything of my own, knowingly to escape, that is in the least contrary to it."

Throughout the whole work the same spirit of honesty and candour is seen, in union with manly boldness, both in forming his judgments, and expressing his opinions.

§ 3. *The intercultural processes of Horse Hoeing.*

Of the train of successive operations belonging to this branch of Tullian culture, the first commenced as soon as the seedling plants shewed the second blade; and it consisted in passing a suitable plough along the outer side of each outer row, and in throwing, in one strong slice, the whole mould of the fallow space into the bared

balk, which thus became occupied by a massive fur of loosened soil obtained from either hand. By this operation, also, the remaining crown of each ridge was so scarped on each side, as to become a flattened ridge, bearing on its surface the seedling rows; and thus stood the autumn-sown wheat all winter.

In this process, says Tull, "we are not so exact as to the weather, in the first hoeing; for if the earth be wet, the hoe-plough may go the nearer to the row, without burying the wheat.

"The greatest fault you can commit in hoeing, is the first time, when the furrow is turned from the row, not to go near enough to it, nor deep enough. You cannot then go too near it, unless you plough it out or bury it with mould, and do not uncover it; nor too deep, unless you go below the staple of the ground. For if the hoe-plough does not at the first hoeing go deep and near to the rows, the subsided earth will, especially in strong land, be as a wall to confine the roots of all the rows from entering the interval in the spring and summer, which is the time they require most nourishment from it.

"In very light land, perhaps, we must not hoe quite so near to the rows of wheat as in strong

land, for fear the winter should lay the roots bare, and expose them too much to the cold; but then we may be sure that in this case the roots will reach the interval at a greater distance than in strong land; yet such very light land is not proper for wheat.

"The outside rows of wheat from which the earth is hoed off, before or in the beginning of winter, and left almost bare until the spring, one would think should suffer by the frost coming so near them, or for want of pasture, but it appears to be quite contrary; for where the hoe has gone nearest to a row, its plants thrive best; the earth, which the frost hath pulverized, being within the reach of the young short roots, on that side of the row from the top to the bottom of the trench, nourishes them at first, and before the plants have much exhausted this, as they grow larger in the spring, the ridge from the middle of the interval is thrown to them, having a perfectly unexhausted pasture to supply their increasing bulk with more nourishment.

"The row standing as it were on the brink of this almost perpendicular ditch, the water runs off quickly, or doth not enter but a very little way into this steep side; so that the earth at the

plants being dry, the frost doth not reach quite to all their roots to hurt them, though the distance from the air to the roots be very short, and dry earth doth not freeze as wet doth, neither is this ditch much exposed to the cold winds."

Respecting the furrow slices feered into the balk, it is most obvious, that no contrivance could be conceived, better calculated to obtain for the removed soil, during the vicissitudes of winter weather, abundant atmospheric impregnation, as well as that most beneficial pulverisation effected by alternate frost and thaw.

"Water, or moisture, when it is frozen in the earth, takes up more room than in its natural state; this swelling of the ice (which is water congealed) must move and break the earth where-with it is mixed: and when it thaws, the earth is left hollow and open, which is a kind of hoeing to it. This benefit is done chiefly to, and near, the surface; consequently the more surface there is by the unevenness of the land, the more advantage the soil has from the frost.

"This is another very great use of the ridge left in the middle of the interval during the winter; because that ridge, and its two furrows, contain four times as much surface as when level. This

thus pulverised surface turned in, in the spring hoeing, enriches the earth in proportion to its increase of internal superficies, and likewise proportionably nourishes the plants whose roots enter it; and that part of it wherein they do not enter, must remain more enriched for the next crop, than if the soil had remained level all the winter."

Then comes spring; when, after the great frosts are passed, and the weather will allow it, the directions are, to split up the balk-ridge, laying a furrow slice against the seed platforms on either hand; in doing which, care less for completely re-emptying the balk of earth, than not to project loose soil from the mould board over the tender wheat rows.

That in this, as well as in the prior opposite process of slicing *from* the rows, some operative dexterity must have been requisite to avoid tearing out the seedling wheats in the one case, and burying them in the other, is no doubt true; and at first, this formed one of the several reasons (the others were mentioned at p. 108,) for Tull's prolonging, at first, his use of the triple rows, the supernumerary third drill acting as a reserve to make up for accidents; but ultimately,

this reason as well as the rest disappeared; "for now, the ploughmen know how to hoe well, they never plough out any part of the outside row;" and as for the other risk of burying, we find him, in a computation of the acreable expenses of his husbandry, thus writing:—"For a boy or a woman to follow the hoe-plough, to uncover the young wheat, when any clods or earth happen to fall on it, which trouble is seldom necessary above once to a crop, two-pence an acre."

But to proceed with the sequel of Tull's yearly course of horse-hoeing processes; and these consisted in alternate summer turnings of the mould of the fallow space, from the rows to the balks, and from thence back to the rows. At last, just as the ripening ears began to shed their bloom, the thus highly impregnated and pulverized soil was heaped up against the flanks of the rows to be penetrated, during the period of fructification, by a fresh and multiplied issue of root threads, which thus were enabled to draw nutriment from every pore, and to transmit it, through the assimilating vessels of the stalks to the ears,—there to be transformed into exuberant productiveness, both in the number and size of the corn grains.

In regard to these summer workings, (of which

Tull himself remarked, that they have "every year the effect of a summer fallow, though it yearly produce a good crop"), the following precepts may be quoted: "As to how many times wheat [or any other kind of corn] is to be hoed in summer after this spring operation, it depends upon the circumstances and condition of the land and weather; but be the season as it will, never suffer the weeds to grow high, nor let any unmoved earth lie in the middle of the intervals [*i.e.* fallow spaces] long enough to grow hard; neither plough (*i.e.* horse-hoe] deep near the rows in the summer, when the plants are large, but as deep in the middle of the intervals as the staple will allow; turning the earth towards the wheat, especially at the last hoeing, so as to leave a deep wide trench in the middle of each interval.

"They object against us, saying, that sometimes hoeing makes wheat too strong and gross, whereby it becomes the more liable to the blacks, or blight of insects; *but this is the fault of the hoer, for he may choose whether he will make it too strong; because he may apply his hoeings at proper times only, and* APPORTION THE NOURISHMENT *to the number and bulk of his plants.*"

What nourishment? We reply; that "manur-

ing power in the air, which modern scientific research tells us, is probably much greater than we conceive,* and which "not confined to periods of rain, and not even limited to the periodical occurrence of dew"† is in the dry heat of summer as in the *moisture* and *cold* of winter and spring, ever ready to yield its blessed influence to soils in proportion to the assiduity of tillage, they receive, at the hands of the husbandman.

The following use of the horse-hoe, suggested by Tull as a remedy for Moor (Root) loose, may here be quoted, as well as his reflections on the cause of that calamity:—

"Another sort of lodging blight there is," (he had just before been treating of those kinds arising from want of air and light, see before, pp. 79, 83,) "which some call Moor loose, and mostly happens on light land; this is when the earth, sinking away from the roots, leaves the bottom of the stalk higher than the subsided ground, and then the plant having only these naked roots to support it, (for which they are too weak,) falls down to the earth.

* Way, "*Royal Agricultural Journal*," Vol. xi, p. 377.

† *Ibid*, Vol. xiii, p. 140.

"To remedy this, turn a shallow furrow against the rows, when they are strong enough to bear it, and when the mould is very fine and dry; then the motion of the stalks by the wind will cause such earth to run through the rows, and settle about the roots and cover them.*

"Some land is very subject to the misfortune of exposing the roots, and therefore is less proper for wheat; for when the roots are left bare to the air, they will be shrivelled and unable to support the plants: and on such lands the wheat plants have all fallen down, though in number and bigness not sufficient to have produced the fourth part of a tolerable crop if they had stood.

"I am inclined to believe, that a thorough tillage might be a remedy to such a loose hollow soil; for it is certain, to a demonstration, that it would render it more dense, and increase its specific gravity; but to enrich it sufficiently, without manure, the tillage must pulverise it much more minutely, and expose it longer than is required for the strongest land. The fold also will be very helpful on such hollow land.

* See also "*Lois Weedon Husbandry*," pp. 78 and 79, where the adoption of the same expedient is described as entirely successful.

"I have never seen any drilled wheat so much spoiled by falling, as sown wheat sometimes is. The drilled never falls so close to the ground, but that the air enters into hollows that are under it, and the wind keeps the ears in motion. Notwithstanding all the precaution that can be used, in some unseasonable years wheat will be blighted. I have known such a general blight, when some of my Lammas wheat, planted late and on blighting land, was blighted amongst the rest of my neighbours', by the insects; but the grain of the sowed wheat was vastly more injured than that of the drilled: the former was so light, that the greatest part was blown away in winnowing, and the remainder so bad, that it was not fit to make bread: the drilled, made as good bread, and had as much flour in it, as the sown wheat had, that was not blighted; for the grains of the drilled were much larger than those of the sown; being formed to have been twice as big as the grains of wheat generally are, had they not been blighted."

§ 4. *The Hand-hoeing Operations.*

These, as may be anticipated, were for the joint purpose of cleansing the interspaces between the

rows from weeds, and of breaking up that incrustation which at all times is apt to form itself on the surface of long-unstirred soil, thereby excluding atmospheric permeation.

"This hand-hoeing should be performed about the end of March or beginning of April, before the wheat is spindled (*i. e.*, run up to stalks) and, if the weather be dry enough, you may go lengthways of the ridges with a very light roller to break the clods of the partitions,* whereby the hoe will work the better.

"If there should, afterwards, more weeds come up, they must not be suffered to ripen; and then the soil will be every year freer from weeds.

"This hand-hoeing of the rows should be done at the proper time, though it happen, by late planting, that the horse-hoe has not gone before it; for it may be, that the weather has kept out the horse-hoe; and the earth may not be dry deep enough in the intervals for the hoe-plough, but deep enough in the partitions for the hand-hoe.

"And the expense of this hand-work on the rows

* This expedient also has been followed at Lois Weedon, with success, in preventing falling through weight.

would be well answered, though there should not be one weed in them; and so it would be, if a second hand-hoeing were bestowed on the partitions of every crop of wheat not suspected of being too luxuriant.

"If, after the last horse-hoeing, there should be occasion for another hoeing of the intervals, where the narrowness of them, and the leaning of tall wheat, make it difficult or dangerous to be performed by the hoe-plough, a slight shallow hoeing may be performed therein by the hand-hoe with ease and safety, at a very small expense, which would be more than doubly repaid in the following crops.

"I should say that, in hand-hoeing, the earth must never be turned towards the wheat, for, if it were, it might crush it when young; neither could the partition be clean hoed. The hand-hoes, for hoeing the ten-inch partition, have their edges seven inches long; they are about four inches deep from the handle; if they were deeper they would be too weak, for they must be thin and well steeled." For treble rows, the hoers "use hoes of four inches in breadth, very thin and well steeled; their thinness keeps them from wearing to a thick edge, and prevents the necessity of

often grinding them. Such hoes are in use with some gardeners near London. They need not be afraid of drawing these little hoes across the rows of young wheat, to take out the few weeds that come therein at the early hoeing; for, whilst the wheat-plants are small, it may be an advantage to cut out some of the weakest, as they do of turnips; for I perceive there are oftener too many plants than too few."

§ 5. *Of Reaping.*

"Reaping this wheat" [*i. e.*, horse-hoed wheat] "is not worth" [*i.e.*, does not cost] "above half as much as the reaping of a sown crop of equal value; because the drilled standing upon about a sixth part of the ground, a reaper may cut almost as much of the row at one stroke, as he could six, if the same stood dispersed all over the ground, as the sowed does. And because he who reaps sowed wheat, must reap the weeds along with the wheat; but the drilled has no weeds; and besides, there goes a greater quantity of straw, and more sheaves, to a bushel of the sowed, than of the drilled.

"One sheaf of the latter will yield more wheat than two of the former, of equal diameter.

§ 6. *Of preparing the Stubbles for the next Crop.*

On entering on this section we would remind the reader, first: that what we are describing are processes of unintermittent or successive corn culture; and, secondly: that, during the entire summer, the bare fallow spaces have been receiving a thorough tillage, highly favourable to the fecundity of the adjoining corn rows; and it will now, at a glance, be perceived, how singularly beautiful is the subservience, also, of the summer working, to the preparation of a finely mellowed seed bed for the succeeding crop; and we shall now proceed to give Tull's directions for preparing the stubbles for the next sowing. "As soon as conveniently you can, after the crop of wheat is carried off, if the trench in the middle of each wide interval be left deep enough by the last horse-hoeing [*i. e.*, if the balk between each two adjacent fallow spaces was completely cleared of soil, by that final horse-hoeing operation, which banked up the summer worked soil on the ripening corn] go as near as you can to the stubble with a common plough, and turn two large furrows into the middle of the interval, [balk] which will make a ridge over the place where the trench [balk] was; but if the trench be not deep enough,"

i. e., was not bared to the subsoil] "go first into the middle of it with one furrow, which, with two more taken from the ridges," [*i. e.*, one from each adjoining ridge] "will be three furrows in each interval. *It is the* DEPTH *and* FINENESS *of this ridge, that the success of our crop depends on*, the plants having nothing else to maintain them, during the first six months; and if, for want of sustenance, they are weak in the spring, it will be more difficult to make them recover their strength afterwards, so fully as to bring them to their due perfection." "Continue" adds Tull "this ploughing" [*i. e.* the forming of the seed bed,] "*as long as the dry weather lasts*, and then finish by turning the partitions whereon the last wheat grew, up to the new ridges, which is usually done at two great furrows. You may plough these last furrows, which complete the (new) ridges in wet weather,—but, the two furrows of every ridge whereon the rows are to be drilled, we plough dry; and if the weather prove wet before these are all finished, we can plough the other two furrows up to them, until it be dry enough to return to our ploughing the first two furrows; and after finishing them, let the weather be wet or dry, we can plough the last two furrows.

"In making ridges for wheat after wheat, you must raise them to their full height, before you plough the old partitions, with their stubble, up to them; for if you go about to make the ridges higher afterwards, the stubble will so mix with the mould of their tops, that it may not only be a hindrance to the drill, but also to the first hoeing; because if the hoe-plough goes as near to the rows as it ought, it would be apt to tear out the wheat-plants along with the stubble.

"It is not best to plough the stubble up to the ridges, until just before planting, (especially in the early ploughing), because that will hinder the re-ploughing of the first furrows, which, if the season continues dry, may be necessary: sometimes we do this by opening one furrow in the middle of the ridge, sometimes two, and afterwards raise up the ridges again; and when they are become moist enough at top (the old partitions being ploughed up to them), we harrow them once (and that only lengthways) and then drill them."

Although, however, the soil of the fallow spaces might be *feered* into the new seed bed, over the entire farm, before the stubble space was *hented*, it remained unfit, until that latter operation either wholly or field by field was completed, for

the subsequent harrowing and drilling; because without the backing of the more tenacious stubble slices, the fine mould of the seed beds would in the harrowing be levelled down; but thus supported, "we harrow them *once*, and then drill them."

"But if once be not sufficient to level the tops of the ridges fit for the drill to pass thereon, as it always will, unless the two last hard [stubble] furrows lie so high that all the shares of the drill cannot reach to make their channels, and in this case you must harrow again until they can all reach deep enough.

"Our ridges, after the first time of ploughing, excel common ridges of the same height; because these, though as deep in mould at the tops, have little of it tilled at the last ploughing; but ours, being made upon the open trenches, consist of new-tilled pulverized mould, from top to bottom.

"If the feerings whereon the next crop is to stand," [*i.e.* the new seed bed] "be ploughed dry, we may drill it at any time during the common and usual wheat seed time, that is proper for the sort of wheat to be drilled, and the sort of land: whether that be early or late, we may drill earlier, but not later than the sowing farmers. But I have had good crops of wheat drilled at all times betwixt

harvest and the beginning of November." Again; "we not only plough a deep furrow, but also plough to the depth of two furrows; that is, *we treneh-plough where the land will allow it;* and we have the greatest convenience imaginable for doing this, because there are two of our four furrows always lying open; and two ploughed furrows (that is one ploughed under another) are as much more advantageous for the nourishing a crop, as two bushels of oats are better than one for nourishing a horse. Or if the staple of the land be too thin or shallow, we can help it by raising the ridges prepared for the rows the higher above the level.

"Very little of my land will admit the plough to go the depth of two common furrows without reaching the chalk; *but deep land may be easily thus treneh-ploughed with great advantage*; and even when there is only the depth of a single furrow, that may sometimes be advantageously ploughed at twice."

And now that we have completed our epitome of Tullian culture, we would dwell for a moment, on two most important circumstances belonging to that mode of Tillage, namely, 1st—the small amount of time and work required to prepare a great breadth of land for seed; for, says he, "we can

plough our two furrows [composing the seed bed] in the fourth part of the time they [the old husbandry farmers] can plough their eight, which they must plough dry, *all of them*, on every six feet; for they cannot plough part dry and the rest when it is wet, as we can."

The 2nd circumstance is—its general economy of labour. Thus, for instance, each prior operation is in harmony with and even promotive of that which is to follow it. The earth removed by *gathering*, to form the open balk, by the same action, deepens the staple of the ridge by a fourth or third part, (according as six feet or four feet eight inch ridges are used), while the open balk itself permits the alternate movement of the earth of the fallow spaces, and then becomes the appropriate site of next year's seed bed. The summer fallow workings not only promote the fertility of the adjacent corn rows in their various stages of growth and maturation, and prepare the soil for the ensuing crop, but wage a war of complete extermination with every thing of the nature of weed. The same open spaces which give room for interculture, also promote the freest possible circulation of air and accession of heat and light as respects both the soil and the growing plants. The

horses walking on the balks avoid the injurious pressure of their weight on the loosened mould. No grass divisions, beat hard by the feet of animals, give rise to the laborious tillage of breaking up leys; while, finally, no dunging in spring, and carting of root crops in winter, undo by poaching, the tilth of the previous fallow operations.

CHAPTER X.—WHAT THE REMUNERATIVE SUCCESS OF TULL'S FARMING.

1, Of His Success.—This Testified at the Time by the Public Voice.—The Evidence of his Book on the Subject.—Arthur Young's Conclusive Testimony on this subject.—§ 2, Why Tull's Principle of Tillage a Substitute for Manure was never introduced into Corn Husbandry.—This Owing partly to Prejudice.—But chiefly to the then Opposing Advantages of Alternate Husbandry. —§ 3, The Original Reasons for Alternate Husbandry, now much modified.—Tillage Implements immensely Improved.—Extreneous Manures must induce a change of Cultural Practice.

§ 1. *What the Renumerative Success of Tull's own Farming?*

On this subject Tull's work contains no direct evidence.* But, however interesting it would be to peruse his barn accounts, were they extant, the absence of any specific information in the volume, on this subject, exposes its narrative to no suspicion of concealment of unsuccessful results; because, in truth, the book itself was the offspring of a foregone conclusion of success, known of

* It has been seen at p. 37, that the notes of his experimental admeasurements, and weighings, intended for publication, were lost in preparing for the press.

many famous witnesses who sought its publication, not to scan the particulars of his harvest returns, but, to be taught the way by which that fertility of his corn fields, seen and acknowledged by all the world, had been attained.

That, on the whole, he raised much better crops than did his neighbours, farming on the old system, is consonant with every ingredient of internal evidence contained in his statements; these, moreover, being characterized by a valorous and frank tone of expression, every way significant of entire candour and truthfulness. Again; how inconceivable it is, that this sorely afflicted invalid, even with all his indomitable energy, would for several years prior to his death, have extended his intercultural and unintermittent corn growing to considerably upwards of one hundred acres of wheat of a season, had he not fully proved its profitableness.

Exposed, too, as he must have been during the earlier years of his new system to extraordinary practical difficulties, and much unremunerative outlay in trials, the natural presumption might have been, that he could hardly have avoided impairing his fortune; and such, accordingly, was one of the malevolent aspersions which the Book-

sellers' hirelings of the day circulated of him. Not denying his success in harvest results, these anonymous writers first attributed it to the falsely alleged richness of his land; and then, said they next, At least he has "drilled away" his inheritance! To this, he replied in the following dignified language:—

"These latent authors must be very conceited of their own penetration, if they pretend to know my affairs better than I do; and if I know them, I have been so far from spending an estate in any manner, that my circumstances are now better than when I first set out in the world, notwithstanding many uncommon and inevitable misfortunes of divers kinds that have befallen me; amongst which, the loss of health, obliging me to quit the profession to which I was bred, and to travel for saving my life, may be reckoned.

"It is to the new husbandry that I owe the property of my farm, and all that I here have said I can make appear to any gentleman, whose curiosity shall induce him to inquire of me, to find the truth for his satisfaction. My estate is not so large as to leave an overplus for acquiring another, after the expenses of maintaining me in the manner I have been accustomed to live. I

propose no more than to keep out of debt, and leave my estate behind me, better than I found it; which, unless some new accident prevent, I shall perform; though generally the first inventor of a project is a loser. But my scheme diminishes the usual expense so much, that one who understands it can scarce be in danger of losing by it; yet, owned it must be, that had I, when I first began to make trials, known as much of it as I do now, or as the diligent reader of my Essay and this Appendix may, the practice of it would have been more profitable to me."*

In a succeeding chapter it will be seen, that no inconsiderable reflected light, suggestive of even a high amount of productive success in Tull's farming, is derivable from the well-ascertained

* In 1794, Arthur Young visited Prosperous Farm, (then belonging to a gentleman who had bought it from Tull's son, after his father's death) and made careful enquiry, of those who personally knew Tull, regarding the reputed ill success, pecuniarily, of his farming; and thus Young wrote on the subject:—"As Tull had been reproached, by the writers on his works, with *drilling away* his fortune, I was anxious to enquire what the fact was, and had the pleasure to find that the imputation was without foundation."—*Annals of Agriculture, Vol.* 23, *p.* 173.

details of that experimental reproduction of his system, which has become so well known at Lois Weedon.

§ 2. *How Tull's system of Interculture, although generally adopted in the culture of Fallow crops, has not hitherto been introduced into Corn Farming.*

On entering on this subject, it is in the first place to be remembered, that the adoption of roots into English farming, and the substitution of them and of pulse as cleansing crops in place of the bare fallow, were in a great degree coincident with the promulgation of Tull's horse-hoeing method. Again, those who have studied the progress of agricultural improvement in manipulative procedure, will readily conceive, that the same race of farmers, who, in commencing for the first time the expedient of fallow cropping, would be as willing to go by Tull's rules in that branch of culture, as any other, might nevertheless spurn the idea of subjecting their corn crops to a management, which, like Tull's intercultural system, was so completely at variance with their already rooted habits and prejudices in cereal husbandry. Accordingly, that a bigotted opposition of this kind actually pre-

vailed is very certain; and thus Tull himself graphically relates it in the following quotation. "Whatever accident," he writes, "even from the heavens—as lightning, tempest, a wet harvest, or from cattle, or the like—happens to *drilled corn*, it is sure to be imputed to the drilling, though sown corn be as much or more damaged by it."

Even the enlightened Arthur Young, himself, was not above the prejudices of the day against the New Husbandry, as we have already seen Tull's system came to be called; supporting his opposition on the following among other futile or ephemeral grounds. He prophesied (how untruly, subsequent events have since shewn) that both the thin sowing and the drilling of corn would increase the prevalence of mildew. Absolutely denouncing all manner of interculture in the growing corn, he even doubted the advantage of drilling the roots, or the use of any instrument amongst them in their growth, save the hand-hoe. He dogmatically asserted that any system of corn culture without dung must needs be a delusion. He opposed horse-hoeing, because it was impracticable in wet land, requiring to be water furred, not reflecting that draining was the appropriate remedy for this objection. No system of tillage,

he argued, inconsistent with Alternate Husbandry (of which he was the great advocate) was rational, or could be otherwise than unprofitable; and he laboriously urged that whatsoever mode of corn farming, which, like Tull's, engrossed a part of the farmer's attention between seed time and harvest (thistling excepted!) was inconsistent with any practicable routine of management. By this time Tull had been dead nearly thirty years, leaving his mantle behind him on no one; and thus from the unopposed, as well as perspicuous and indefatigable pen of Arthur Young, arguments like these, tending to rivet more firmly the ancient notions of corn tillage, received very willing and general acceptation. Accordingly, in process of time, Tull's teaching in that branch of agriculture was completely overborne. That Young lived long enough to see cause for retracting most of his objections to Tullian practice in general husbandry, will afterwards be shewn; but undoubtedly his writings are the main source of that tradition respecting Tull prevalent amongst the agricultural community of the present day—namely, not that in point of fact he taught them how to seed and drill their corn fields, and how to till their fallow crops, as they are at this day sown, drilled, and tilled,

but as that speculative enthusiast who originated the idea that corn could be grown unintermittently without degeneration, and unmanuredly without sterility.

But although Young's objections to Tull's methods of cultural manipulation have been completely overruled by modern practice, it is impossible, so far as respects his advocacy of Alternate Husbandry, not to attribute to it the most important benefits to English agriculture, or not to acknowledge that its successful opposition, *for the time*, to Tull's system of corn growing—*bread cast on the waters to return again after many days*,—was greatly for the national advantage.

This will shortly be treated of in the next section.

§ 3. *Of the original reasons for Alternate Husbandry, and of their now greatly modified cogency.*

A strong motive for lessening the proportion of corn growing on farms, as practised under the Old Husbandry, (and which the interposing of green crops enabled the farmer to accomplish), existed in the then great defects of the Tithe system, now happily placed on a footing, no longer

at variance with a renewed extension of cereal cultivation.

But chiefly it is to be remembered, that at the time Arthur Young was successfully disseminating his doctrines of Alternate Husbandry, the condition of landed property throughout England was such, that not within the entire kingdom did there probably exist a single farm approaching even the condition of thorough improvement, insomuch that wheresoever the eye now ranges with delight over districts composed of well proportioned, well inclosed, and well drained tillage or pasture fields, their prevailing characteristics, at the period in question, were those of either neglected wastes, or ill-arranged and uninclosed patches of cultivation, most frequently in intercommonable occupancy.

Now that the subsequent reclamation of the national husbandry from these fundamental defects of the old system was the work of *various* industrial agencies, is very certain. At the same time, in so far as the amelioration of the soil itself progressed hand in hand with the other branches of improvement, it is unquestionable, that the specific benefits belonging to Alternate Husbandry in its improved intercultural tillage of the

fallow crops, and in its increased supply of cattle court manure, must have been of most essential importance.

But, is it an unavoidable necessity, that the same modes of husbandry, proper to such a condition of farming as we have been adverting to, shall still be perpetuated in those leading tillage districts already subjected to thorough improvement? Are the agricultural resources and polity of the corn counties of England, the same, at the present day, as when rotations were first introduced into Norfolk, or borrowed, from thence, by the other eastern divisions of the kingdom? Granting that the unskilled labour, and imperfect tillage mechanism of the last century, and earlier part of the present, were insuperable barriers to the extension of Tullian interculture to the corn crops; are not these obstacles now removed? Granting that the manufacture of cattle court manure, was formerly an indispensable expedient on every corn farm, who will assert that in this, the age of extraneous fertilizers, it longer is so? If, under the alternate system, the clover plant has sickened, and the turnip acquires its unnatural bulk, only to become a mass of corruption; if, finally, under this husbandry, even cereal vegetation is exhibiting unequivocal symptoms of deteri-

oration,* surely the time has arrived when both the owner and occupier of improved tillage property should remember, that the device of alternating cattle crops with corn, was a mere graft on a prior unalternate cereal system, of which the history, from remote times, was that of increasing prosperity, and which now, with greater or less modification, could again be resumed, under circumstances inexpressibly more favourable to success, than when it formerly was the national tillage husbandry of England.

In concluding this chapter, we would, however, earnestly direct the reader's reflections to the following quotation: "The profit or loss," reasons Tull, "arising from land, is not to be computed only from the value of the crop it produces, but from its value after all expenses of seed, tillage, &c., are deducted;" a maxim which the unthinking may regard as a mere truism, but of rare significance in testing and estimating, as will afterwards be done in the next chapter, the economic and profitable merits of TULLIAN COMPARED WITH ALTERNATE FARMING.

* See extracts from a discussion in the Central Farmers' Club, on the question "What system of cultivation, upon mixed soils, will, under present circumstances, be found most profitable?" *Appendix*, No. II.

CHAPTER XI.—OF INSTANCES SUBSEQUENT TO TULL'S OF INTERCULTURAL SUCCESSIVE CORN HUSBANDRY WITHOUT MANURE.

Lois Weedon instance.—In every respect Tullian in principle.—The Work on "Lois Weedon Husbandry" quoted.—The Narrative of it, and Tull's Book on the Subject of Acreable Produce compared.—Their mutual similarity.—Eight other Experimental Instances, tabulated.

Of the instances in successive corn growing, subsequent to Tull's, the most noted one is the Rev. T. Smith's adaptation of the system at Lois Weedon.

His plan is as follows: he divides his field into lands five feet wide, and in the centre of each he drops or drills the seed in triple rows, one foot apart, thus leaving a fallow interval of three feet between each triple row; when the plant is up, the intervals are trenched with the spade or fork, taking the spits about three inches from the wheat; and at spring, and during summer, he cleans them, and keeps them open with the horse-hoe and scuffler. Every year, in short, he trenches and cultivates two and a half feet out of the five, for the succeeding crop, and leaves the

other two and a half for that which is growing. The next year the wheat is sown in these fallow intervals, and the stubble is broken up in like manner for the fallow process. Thus the ground is freely opened to the action of the atmosphere: and, to deepen the soil, the thickness of the cultivated staple is very gradually increased, by digging a few inches deeper each time, till, ultimately, a depth of twenty-one inches of thoroughly stirred earth is attained; but the last four crops have been grown (it is understood) on intervals worked only half depth.

The first subject of Mr. Smith's trial was a one acre plot of good clay land, estimated at thirty-two shillings of yearly rent, and naturally adapted to wheat tillage. In the season of 1846, the experiment commenced; his first Tullian harvest having been that of crop 1847, and yearly, from that time to the present, it has borne successive unmanured wheat; and this is the acre referred to in the outset of the preface, as that which in especial has attracted so large a share of public interest. Resolving to increase the scope of his experiment, in October 1850, Mr. Smith took in hand other four acres, and to which, consisting as it did of a gravelly soil, naturally unfitted

for wheat growing, he gave adequate strength for that purpose, by a most judiciously managed top dressing of clay.

From both instances the yield has been at the acreable rate of from thirty-four to thirty-five bushels of marketable grain; (see Table II.) and altogether they are to be regarded as forming an admirably conducted, and successful experiment, confirmatory, as well as illustrative, of the catholicity of Tull's actual farming, on a twenty-fold greater extent.

But, in no respect, does the Lois Weedon experiment admit of any claim to originality, although their estimable author would seem to have thought them entitled to that distinction, in several particulars. Let us, with all candour, and with no disposition to detract from his well-earned fame, examine these pretensions.

Conducted by the spade or fork, in place of the plough, even *that* is not original, since spade work is precisely what Tull himself recommended in his instructions to experimenting disciples. But, says this disciple, I claim as an originality, in that while Tull forbids the plough to pass below the staple, I boldly drive the fork to the depth of thirteen inches, and bring to the surface a yearly

modicum of fresh subsoil. What Tull really warned against, however, was, the disturbance of an unprofitable bottom, like his own chalk, or a positively pernicious one, like many underclays and gravels throughout the country; and to say that his writings contain a word of injunction against deep cultivation to bring up a mellow clay marl, such as the very ingenious experimenter at Lois Weedon, has to deal with, is a complete misconception. "We trench plough," Tull says, "where the land will allow it; and two ploughed furrows (that is, one ploughed under another), are as much more advantageous for the nourishing a crop, as two bushels of oats are better than one for nourishing a horse."

Again: the omission in Lois Weedon practice, of what Tull to the last practised, namely, the expedient of slicing a fur from the young wheat, in early winter, is claimed as an originality. But Tull made no absolute point of this operation, for, he says, "if the wheat is planted very late, it may not be hoeable before winter is past," thereby giving a discretionary license to practice or omit the pre-winter hoeing, as experience might dictate.

SMITH.—"I claim the originality of bringing

up the subsoil, without injuring the plant, but, on the contrary of giving shelter to it by the ridges of each interval."—*Lois Weedon Husbandry*, p. 111.

TULL.—"We also raise a high ridge in the middle of each interval above the wheat, before winter, to protect it from the cold winds, &c." This expedient, however, it may here be mentioned, Tull ultimately abandoned when he ceased drilling on the level, (which in his earlier practice he had done) and took, finally, to ridges. "I have for these several years left off drilling on the level, and do advise against it; because, although mould should not be wanting for the partition in deep rich land, yet it is much more difficult to (horse) hoe on the level than on ridges."

SMITH.—"I claim the originality, as compared with Tull, of narrowing the intervals, &c."—*Lois Weedon*, p. 112.

TULL.—"I cannot prescribe precisely the most proper width of all intervals, because they should be different in different circumstances. In deep rich land they may be a little narrower than in shallow land."

Thus, then, these, the only differences claimed by the Rev. Mr. Smith as existing between his method and that of his great teacher are shewn

to be destitute of any real distinction. It follows, therefore, that as like causes will always produce like effects, the respective published recitals of the two instances may reasonably be expected when placed, as shall now be done, in juxtaposition, to possess such frequent coincidences and analogies as may reflect back, from the junior to the elder testimony, more or less of interpretive light, to enable us the better to form some specific conception of what Tull's returns may have been.

"During winter," writes Mr. Smith, of his own experiment, "and up to April, the plant looked so thin and so very far between, as almost to excite ridicule. The wheat, however, began then to mat and to tiller. May came; and all through that trying month it kept its colour, without a tinge of yellow. And now the well tilled intervals have told upon the grain, which has swollen to a great size. The compact ears are enormously heavy and large. The reed-like straw has borne up against the storms. And there, at this moment, as level and as laughing as the slightly rippled sea, stands as fine a crop of wheat as ever I beheld, promising from the half portion of each acre, a yield of from 36 to 40 bushels."—*Royal Agricultural Journal*, Vol. xii, p. 134.

If, then, from four to five quarters an acre is the well earned meed of Lois Weedon judgment and skill, what less reward must have belonged to him whose graver narrative runs thus: "The horse-hoed," says Tull, "shews the whole interval empty until the grain is almost full, which is a great advantage to the crop; because, unless the air did freely enter therein to strengthen the lower parts of the stalks, they would not be able to support such prodigious ears (some containing 112 large grains a-piece) from falling on the ground.

"When the grains are full, the ears turn their upper ends downwards, and are all seen in the intervals, and nothing but straw on the rows; this reverse posture of the ears defends them from the injuries of wet weather when ripe; for the rain is carried off by their beard and chaff, which, like tiles, protect the grain from being discoloured, as sown wheat always is by much rain, when ripe.

"This difference was fully shewn the last harvest, when all my wheat was in the same posture; none of the ears reached the ground, but some reached within a foot, others within half a yard of it, and some not so low; none of the straws were broken by the weight of those large ears, they only bended round at the height of about a yard

or higher, in a manner that I never saw in any other wheat but the horse-hoed.

"In these intervals, notwithstanding this bending posture of the ears, one may walk backwards and forwards without doing any damage; for the ears when thrust out of their places, will, by their spring, return to them again like twigs in a coppice.

"Imagination often deceives us, by arguments false, or precarious; but reason leads us to demonstration, by weights and measures. Yet this prejudice (*i.e.* that wheat standing in rows, with wide intervals between them, may not seem to the eye to equal a crop of half the bigness dispersed all over the land) will vanish at harvest before weighing; *for then all those wide intervals that were bare, will be covered with large ears interfering to hide them quite, and make a finer appearance than a sown crop.* But it is observed, that the cone-wheat makes the finest show when you look on it lengthways of the rows, both at harvest and a considerable time before harvest."*

* "Unquestionably," writes Cobbett, "a field of Tullian wheat in ear, with the ridges straight and the land clean, is the most beautiful thing in the vegetable world. It is not *grand*, like the Indian corn; but it is even more beautiful than that. After three or four crops, there is very little

SMITH.—"I have now the fifth crop on the same acre of unmanured land," (the twelfth has since been reaped) "promising at least from the half portion of the acre, the customary yield of 34 bushels: many place it is as high as 40."—*Royal Agricultural Journal*, Vol. xii, p. 135.

TULL.—"My field, whereon is now the thirteenth crop of wheat," (but he had other fields at the time, under the same treatment) "is likely to be very good;" the previous crop having been, as he elsewhere relates, the best that ever grew on it.

SMITH.—"The ten years average" (written in 1857) "from this moiety of the acre has been 34 bushels; a very high average on any plan from a whole acre."—*Lois Weedon*, *p.* 79.

TULL.—"The goodness of a crop consists in the quality of it, as well as the quantity; and wheat being the most useful grain, a crop of this is better than a crop of any other corn; and the hoed wheat has larger ears and a fuller body than sown wheat. · We do not pretend that we have

trouble from *weeds* or *grass*. The land is prepared for any crop; and it is bearing a good crop, while the preparation is going on."— Cobbett's *Introduction to Tull*, p. xvii.

always greater crops, or so great as some sown crops are. The greatest produce I ever had from a single yard in length, of a double row, was eighteen ounces; the partitions of this being six inches, and the interval thirty inches, was, by computation, ten quarters, or eighty bushels to an acre. I had also twenty ounces to a like yard of a third successive crop of wheat; but this being a treble row, and the partitions and interval being wider, and supposed to be in all six feet, was computed at six quarters to the acre."

SMITH.—"I expect a similar crop, year after year in the same four acres of land, treated in the same way. I do so, because experience justifies my expectation, and, as I conceive, science confirms it."—*Royal Agricultural Journal*, Vol. xii, p. 134.

TULL.—"The more successive crops are planted in wide intervals and often hoed, the better the ground does maintain them. The last crop is still the best, without dung or changing the sort of plant."

That Tull's average produce from the whole 120 acres which latterly he had under wheat of a season, was not nearly equal to that which has been instanced above is quite certain; indeed, he

frankly records several failures attributable to his inability, in winter, himself to supervise the field operations. Nevertheless, in Lois Weedon success, we doubtless have a faithful picture in little of those harvests at Prosperous, which, unsought of him who tilled them, blazoned abroad his agricultural triumphs through every corner of the empire.

It has, indeed, pleased the disciple, writing of his venerable master, to remark that, "from a few scattered intimations here and there, and from the early editions of his (Tull's) work, published in and about his time, we may gather that his general produce per acre was about two quarters."—*Word in Season*, 15th edition, p. 36.—This is not the language of accurate, reliable, or (shall we venture to say) impartial inquiry; and assuming Cobbett's edition of Tull's volume to be a faithful transcript of the original text, this disloyal underrating of the great teacher's practical success is controverted by one continuous train of internal evidence to the contrary. But probably the following piece of external contemporary testimony will not be unacceptable to the reader. In the *Museum Rusticum* of 1765, there is to be found an able contribution, bearing to have been written partly

from the study of Tull's writings, and partly from intimate intercourse with a contemporary and personal acquaintance of Tull—namely, the experimenter No. 2 of the following Table I; and in this paper the average of Tull's last wheat crop (upwards of 100 acres in extent), is estimated at nearly 20 bushels of 9 gallons per bushel, equal to 22½ bushels imperial. But ere this, the final year of Tull's farming, his infirmities had, as the writer justly remarked, prevented his giving anything like adequate superintendence to the management of his farm, and accordingly, the article is evidently written under the persuasion that Tull's prior returns were considerably greater.—*Museum Rusticum*, vol. iii. pp. 159, 341; vol. iv. p. 81.

An able writer, in the *Agricultural Gazette*, of January 5, 1850, concludes, "that Tull annually grew above three quarters of wheat to the acre," and this quantity has been adopted in the following tables, as being incontestibly within the mark.

The other ascertained instances of Tullian corn culture, are epitomized in the following table.

TABLE I.

	Experimenters' Names.	Acreage.	DESCRIPTION OF SOIL.	Rent per Acre.	Date.	No. of years embraced in the Experiment.	Acreable Produce in Bushels of Wheat.
			1. WITH THE PLOUGH.	s. d.	From		
1	Jethro Tull	120	A thin chalk.....	10 0	1712 to 1735	13	24
2	Mr. Dean	(?)	"Soil of a very stiff obdurate tending quality, and difficult to keep in good tilth" *....	15 0	1744 to 1764	20	27
3	Rev. W. Close ..	5	"Not what is termed good turnip land, but a mixed loamy soil rather springy" †	20 0	1782 to 1785	3	24
4	Mr. Budd	(?)	(?) ‡		1790 to 1794	4	21⅛
5	Mr. Beaman....	(?)	"A stiff dark-coloured loam upon a marl and clay bottom" §		1816 to 1822	6	23
6	Mr. Box	1	Land of average quality‖		1825 to 1832	8	27⅛
7	Mr. Clarke	10	"Soil and Subsoil, a strong alluvial loam, not well drained, but sandy earth at considerable depth" ¶	40 0	1857 to 1858	2	26⅝
						7)	173¼
			Average per Acre				24·3

NOTE.—For aught known to the contrary, Nos. 3, 4, and 5 may have been continued with similar success for many more years.

* *Museum Rusticum*, vol. iii. pp. 159, 341 ; vol. iv. p. 81. † *Bath Agricultural Journal*, vol. iii. 1st series, p. 225. ‡ Young's *Annals of Agriculture*, vol. xxiii. p. 178. § Corbett's *Edition of Tull*, Introduction p. xv. ‖ *Morton's Cyclopedia of Agriculture*—Art. "Drill Husbandry." p. 714. ¶ On the authority of the Experimenter, Mr. J. A. Clarke, of Long Sutton, Lincolnshire, who, writing on 30th of May, 1859, remarks, "My present crop" (being the fifth successive corn crop without manure, and third on the Tullian system, see next Table), "at this time, looks better than either of the crops which preceded it ; and though it is premature to speculate on the quantity of produce now, I reasonably look for a yield of at least 32 imperial bushels per acre."

2. WITH THE SPADE OR FORK.

					From		
8	Rev. Mr. Smith .	1	A good Wheat Clay Soil*	32 0	1846 to 1858	11	35
9	„	4	A clayed gravelly Soil*	32 0	1851 to 1858	8	34
10	Mr. Jones	½	"Soil and Subsoil, a gravelly loam, the gravel preponderating" †		1850 to 1858	8	36⅛
11	Rev. Sir George Robinson	4½	"Soil, a mixed sandy clay—Subsoil, a stiff clay" †	35 0	1819 to 1858	10	28½
						4)	134
			Average per Acre				33·2

* "*A Word in Season*," and "*Lois Weedon Husbandry*." † On the authority of the Experimenters.

NOTE.—It may be proper to explain why the Rothamsted experiment "On the Growth of Wheat by the Lois Weedon System," has been omitted from this tabulation. Indeed it is not cited by the experimenters themselves as a Tullian experiment—and except in the single circumstance of the seed having been sown in triple rows, at intervals, no other Tullian practice is observable in the report of the trial ; while on the other hand, several vital Tullian principles were positively violated in its performance. Thus, then, the experiment not being after the manner and precepts of the Master, it signifies little whether it possesses any resemblance to the method of a minor school, the more especially since it has been absolutely repudiated by the head of that school also.—See Lawes and Gilbert, "On the Growth of Wheat by the Lois Weedon System," &c.—*Royal Agricultural Society's Journal*, vol. xvii. p. 582 ; and "Lois Weedon Husbandry," by the Rev. S. Smith.—*Ibid*, vol. xviii. p. 30

TABLE II.

SHEWS THE ACREABLE PRODUCE OF EACH SUCCESSIVE YEAR IN THOSE INSTANCES WHERE THE PARTICULARS ARE RECORDED.

No.		Previous Common Husbandry			TULLIAN HUSBANDRY.										
	BY THE PLOUGH.														
3	Mr. Budd	?	?	?	26	18	Oats	20							
6	Mr. Box				32	32	30	17½	20	30	26½	29			
7	Mr. Clarke (See App. No. II.).	Bns.	Wht. unma	By. nurd.	23	30									
	BY THE SPADE OR FORK.														
8	Mr. Smith (Lois Weedon)* ..	?	?	wht.	34	34	34	28	34	34½	34¼	40	37	36	40
9	„	?	?	wht.	41	32	32	40	25	34	34				
10	Mr. Jones.....	unma ?	a n u ?	red. ?	41	32	32	35½	30	40	38½	44			
					197	178	128	141	109	138¼	133¼	113	37	36	40
	Average				33	29½	32	28	27	34½	33	37½	37	36	40

B. 27¾ — Average of the first 5½ crops.

B. 38½ — Average of the 2nd 5½ years crops.

Average of the whole, 33 bushels.

* The produce of the first experimental year of the clay piece was not registered.

Thus, then, an examination of this Table will shew, that Tull's assertion that his own soil increased in productiveness, and, that generally, thorough tillage is competent to sustain uninterrmittent and undiminishing corn cropping unaided by manure, is fully corroborated by these experiments independently conducted at various times, in various localities, and on very various soils.

The yearly acreable expenses of growing Tullian wheat are given in the following table:

TABLE III.

SHEWING THE EXPENSE OF TULLIAN PLOUGH CULTIVATION FOR WHEAT.

ITEMS OF EXPENSE.	Tull, 1735.			Mr. Dean.			Mr. Close 1785.			Mr. Clarke 1858.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Ploughing and other charges up to and including sowing..	0	5	0	0	3	5	0	9	3	0	10	0
Cost of Seed	0	2	4	0	3	0	0	3	1½	0	5	3
Hoeing and other tillage expenses subsequent to sowing	0	4	8	0	5	8	0	6	9	0	16	0
Reaping and other expenses up to and including marketing	0	12	8½	0	12	8½	0	15	9½	1	13	0
Rent, tithe and rates	0	15	0	0	15	0	1	6	6	2	10	0
	1	19	0½	1	19	9½	3	1	5	5	14	3

Now, various in amount as are these charges, there is no difficulty in reconciling them when the well known gradual increase in the cost of

labour, which occurred in the course of the last 123 years, is taken into account; and when also, as respects Mr. Clarke's instance in particular, it is had in view that the larger expenses of reaping, &c., there stated, are occasioned by a more than average rate of produce, and the larger sum of rent, &c. by a more than average quality of soil. Accordingly, in adopting that instance as a criterion of the acreable expenses of Tullian wheat culture by the plough in the present day, a deduction shall be made (in order to reduce it to an average) of 6s. from the expenses of reaping, and of 17s. from the rent; thus lessening the sum total to £4 11s. 3d.

If, then, the average produce of Tullian culture by the plough be taken at 24*b*. 3*p*. of marketable corn (see Table I.) and converted into money at the Tithe average rate of 7s. per Bushel,* the yearly gross produce in money (exclusive of straw) is - - - - - £8 13 3
And deducting from this sum the expenses as estimated above - - - 4 11 3
The nett profit over and above the marketable value of the straw is - - £4 2 0

* The same rate of conversion will be used in the sequel, in all similar calculations.

TABLE IV.

The following calculations are based on the estimated acreable out-goings, in-comings, and ultimate profits (given in Bayldon's Work on Rents and Tillages, Baker's Edition, 1856,) of good Turnip soils in the Eastern counties managed in an ordinary four-course rotation, and assumed to be worth 31s. 6d. of Rent;—the object in citing this authority being to form a criterion, although, perhaps, a severe one, by which to try the comparative profitable merits of Tullian and Alternate Husbandry.

CHARGES.

		£	s.	d.
1.	Expenses of Turnip Division, including Rent Tithe and Rates	11	3	10
2.	,, of Barley Division	5	2	7
3.	,, ,, Clover ,, ...	3	19	10
4.	,, ,, Wheat ,, ...	6	19	10
	4)	£27	6	1
	Yearly expense		£6	16 6

RETURNS.

		£	s.	d.
1.	Turnips valued at	£4	0	0
2.	Barley 40 bus. at 4/ £8 Straw 14/6	8	14	6
3.	Clover	7	6	6
4.	Wheat 32 bus. at 7/ £11 4s. Straw 19/6	12	3	6
	4)	£32	4	6
	Value of yearly returns...		£8	1 1
	Free balance to meet interest on capital, professional remuneration, and risks on live stock		1	5 3
	Profit of Tullian Husbandry (see last page) ...		4	2 0
	Superior profitableness of Tullian Husbandry per acre		£2	16 9

TABLE V.

CONTAINS AN ILLUSTRATION DRAWN FROM TABLES I. AND IV.

The Schedule of particulars given by Bayldon of the expenses of working the Turnip division, contains the following items :—	£	s.	d.
Labour filling manure	0	2	0
Spreading same	0	1	6
Manure and previous labour thereon	3	10	0
Horse and one man carting same	0	4	6
Lime, &c.	0	12	0
	£4	10	0
And amongst the expenses of the Wheat division is ;—Top Dressing in Spring	1	3	6
	4) 5	13	6
Expenses of Manures, divided into an annual sum	£1	8	5

	B.	P.
Now, we have seen, in Table I., that Tullian culture, without manure, can on an average of instances produce a yearly yield of	24	3
Assuming next, that Tullian tillage were supplemented yearly by 28s. 5d. worth of Guano, *i.e.* 2⅓ cwt.; this, according to the usual estimate of the productive power of that manure, would presumably add 4 bus. per cwt. to the acreable product weight, making	9	1
Total Bus.	34	0

Which, converted into money at 7s. per Bushel, gives	£	s.	d.	£	s.	d.
				£11	18	0
DEDUCT :—						
Tullian expenses, as before	4	11	3			
Outlay on Guano	1	8	5	5	19	8
Estimated Profit per acre of Tullian Tillage, supplemented by Guano				£5	18	4

Such, then, is the existing evidence in favour of the great comparative industrial economy, and consequent very remunerative results of Tullian husbandry, conducted by the plough.

Finally, by the spade or fork the comparative amount of Cost and Return is as follows:

TABLE VI.

BY THE SPADE OR FORK, THE COMPARATIVE AMOUNT OF COST AND RETURN IS AS FOLLOWS:

Average produce as shown in Table I., 33 bushels 1peck, which converted into money gives .... £ 11 s. 14 d. 6

DEDUCT	Sir George Robinson. £ s. d.	Mr. Smith. £ s. d.	Mr. Jones. £ s. d.
Expenses up to and including sowing	5 5 0	1 5 0	1 16 0
Cost of Seed		0 4 4½	0 2 8
Expenses of tillage subsequent to sowing		0 12 0	1 8 0
Reaping &c.		1 13 0	2 0 0
Rent, &c.	3 0 0	2 6 0	2 0 0
			7 6 8
			6 0 4½
			8 5 0
		3)	21 12 0½ 7 4 0
			£ 4 10 6
Nett Profits of Alternate Husbandry at Table IV.			1 5 3
Superior Profitableness of Tullian SpadeHusbandry			£ 3 5 3

The following Table of operative details explains itself:

TABLE VII.

WITH THE PLOUGH.	Depth of Cultivation.	Quantity of Seed per Acre.	Number of Rows.	Distance between Row and Row.	Width of Fallow Spaces.
	Inches.	Pecks.		Inches.	Inches.
Jethro Tull	Comn.	3	2	10	46
Mr. Dean	Comn.	3	2	10	46
Mr. Close	Comn.	2	7	4	24
Mr. Clarke.....	9	3	3	10	40
WITH THE FORK OR SPADE.					
Mr. Smith.....	10to21	2	3	12	36
Mr. Jones	?	3	2	10	30
Sir George Robinson	8	3	3	8	36

The author, in concluding this chapter, desires to express his respectful thanks to the Rev. Sir George Robinson, Bart.; J. A. Clarke, Esq., of Long Sutton, Lincolnshire; and H. Jones, Esq., of Lois Weedon; for the information furnished by them severally, and now embodied in the foregoing tables. Other instances he also sought to ascertain, but the information, kindly given, did not apply; and, in a few cases, he received no answers to his enquiries.

CHAPTER XII.—OF THE ROTHAMSTED EXPERIMENTS, AND THEIR BEARING ON TULLIAN HUSBANDRY.

1, Certain characteristics of these experiments stated.—Conducted irrespective of industrial profit.—The Cultural means employed in them not recorded.—They throw no light either on the Theory or Practice of Tillage.—Caird's Observations on them quoted. —They tend to prove that every soil has a tillage *zero*, below which no mode of cropping can reduce its yearly yield.— This Observation already anticipated by Tull.—The *zero* of Rothamsted Successive and Unmanured Corn Culture.—The *zero* of Tullian Culture.—The productive results of the Rothamsted and Holkham experiments in Successive Unmanured and Manured Corn Growing tabulated.—§ 2. The Old Scottish Husbandry cited.—§ 3, These Experiments disprove the Theory of degeneration of species from Successive Culture.—This conclusion also anticipated by Tull.—§ 4, Theory of Nitrogenous Manuring.—Such Manuring competent with only ordinary Tillage to produce abundant Successive Corn Crops.—But Nitrogenous applications, in unfavourable seasons, conducive to deranged functions in the plants.—This objection not applicable to Tullian Culture.—Tull's Practice cited by Professor Way on this point.

§ 1, *The general characteristics of these experiments.*

For the better explanation of the points to be treated of in this chapter, certain well established particulars of Physical Science will be premised respecting the Atmosphere and the Soil in their relations to the Phenomenon of Vegetation.

First, then, of the *Atmosphere*; which may be

defined to be a vast pneumatic reservoir, composed of elemental Nitrogen gas, and designed for the purpose of containing, by means of the gaseous property of *Diffusion*, an ever replenished store of aerial substances concerned in the processes of Vitality; these being, so far as concerns vegetative life—1st. *Oxygen*, uncombined. 2ndly. *Oxygen* and *Hydrogen*, combined in *Aqueous vapour*. 3rdly. *Oxygen* and *Carbon*, in the compound form of *Carbonic acid gas*. And, 4thly, Two other substances, namely, *Nitric Acid* and *Ammonia*,—these being, respectively, compounds of *Nitrogen* and *Oxygen*, and of *Nitrogen* and *Hydrogen*.*

* *Nitric Acid* in combination with other substances, exists in nature in solid mineral forms, of more or less abundance, such as *Nitrate of Soda* (Chili Saltpetre), *Nitrate of Potash* (common Saltpetre), *Nitrate of Lime*, and *Nitrate of Magnesia; Ammonia* is not a natural production, but artificially may be obtained from combination with other substances, such as the *Muriate*, the *Sulphate*, and the *Carbonate* of *Ammonia*. All these substances the intelligent agriculturist will recognize as belonging to the class of *Special Manures;* and as their value, as such, is usually attributed to their nitrogenous basis, and as that basis may upon good scientific grounds, be regarded as of atmospheric origin, they shall accordingly, when spoken of in the sequel

But, although this vast gaseous recipient is always replete with the aereal constituents of organic nature, it is also true, that one and all of these undergo an incessant fluctuation of a kind and to a degree which may not inaptly be typified by the unceasing aqueous evaporation which goes on from the surface of the earth, and its re-precipitation thereon, in the condition of snow, rain, or dew. For, how great soever may be the hourly, daily, or yearly abstraction of atmospheric elements by plants and animals, and how intimate soever their assimilation into organic conditions, sooner or later it is the property of all of them to regain ultimately, by decomposition, their aerial freedom.

But further, in like manner as the nitrogen of the air thus acts as a magazine for *gaseous*

as fertilisers, be called *Atmospheric* manures, in contradistinction to those other necessary nutriments of vegetation, which, existing only in the solid or liquid portion of the globe, and never, except accidently, in the air (such as *Silica, Potash, Lime, Sulphuric, and Phosphoric Acid, &c.*) shall be termed *Terrestrial.* Amongst Chemico-Physiologists, the question has been much agitated, whether *Nitrogen*, in its pure and uncombined state, is nutritious to vegetation; the preponderance of opinion being that, in this state, plants are incapable of assimilating it.

organic nutriments, so, also, do the solid and liquid matters of the globe itself perform the part of repositories for the *terrestrial* food of plants, and, through plants, of animals; and here, also, is there a continual transformation, by virtue of the vital processes of absorption and assimilation, from the inorganic into the organic condition; and of resolution, by decomposition, from the latter back to the former state. To a certain extent these alternate transformations are analogous to those which have just been described, referably to the atmosphere.

But, notwithstanding of this general analogy between these two atmospheric and terrestrial phenomena in connection with vitality, there is, *agriculturally considered*, this most important difference between them:—On the one hand, by no human exertion or contrivance, is it possible to lessen or increase the store of aerial plant food in the pneumatic magazine, either generally or locally; on the other hand, it is of the very nature of tillage husbandry to produce topical depletion of the terrestrial vegetative nutriment of the corn fields, in a degree exactly correspondent with the productive success of the husbandman's industry. In fact, the reduction of a piece of ground from fruitful-

ness to infertility, by over cropping and under tillage, is, of all kinds of evidence, the most palpable, that that soil has been emptied, for the time, of its available ingredients of vegetation.

Now, based on considerations of this kind, it was, that Justus Von Liebig gave expression to his well known dictum, that, in the manurial department of husbandry, the chief object of the farmer ought to be to procure from extraneous sources, and restore to the soil of his fields, those fertilizing mineral, *i.e.*, *terrestrial* substances, which, removed from thence through the causes above-mentioned, could only by that means be restored. The more water is drawn from a cistern, the more need is there that additional springs should be conducted into it.

"Every farmer, who takes a sack of corn, or a cwt. of rape, turnips, potatoes, &c., to the town, ought, like the Chinese coolie, to carry back with him, from the town, an equal (or, if possible, a larger) quantity of the mineral constituents of the produce sold, and restore them to the field from which they have been taken."—*Modern Agriculture*, *p.* 268. As for the application to the farm of its own indigenous manurial products, he demonstrates it to be a restoration of a mere remnant of

what, in the previous season's crop, had been abstracted from the soil; the rest being alienated in the condition of meat, corn, or dairy food sent to market, or wasted by exposure to the elutriation of rainfall, in the dung court or compost heap.

"Respecting the atmospheric nutriments of plants, the teaching of the mineral theorists is, that these are ever in store, and ready to flow to the leaves and roots of vegetation in the fullest abundance, which any fair and unexhaustive method of culture can stimulate them to require. Such, in substance, is the Geissen "Mineral Theory."

Of course, this is not the place to expatiate at large on the grounds on which the authors of the well known Rothamsted experiments have contested the doctrines of the German philosopher on this subject; but the general grounds on which they first urged, and still continue to maintain their argument, are mainly these:—

First. That in cereal cultivation (and to that species of husbandry only shall these remarks be extended) nitrogenous nutriment, especially of the ammoniacal kind, is required in special abundance. Secondly, that while indisputably the nitrogenous

stores of the atmosphere are adequate to supply the nitrogenous wants of all kind of wild vegetatation; yet, thirdly, in order to produce those abnormal conditions of growth in the corn plant, which are necessary to raise the quantum of its products to the standard of profitable farming, it is necessary to supply the soil with adventitious nitrogenous matters to act in supplement of the atmospheric contributions. Fourthly, that in general the *terrestrial*, or, in the language of the controversy, the *mineral* constituents of plants as contradistinguished from those of *atmospheric* origin are seldom deficient in the soil; and, finally, that in the great majority of instances the abundance of a *corn* crop, will, within certain limits and on certain conditions, depend on the proportion of extra nitrogenous matter, especially of the ammoniacal kinds, artificially intermixed, as manure, with the staple.

To prove these propositions, the English experimenters have from time to time conveyed to the public, through the pages of the *Royal Agricultural Journal of England*, elaborate reports of a numerous series of experiments, designed to exhibit the behaviour of the *wheat plant* in its growth: First, *under one uniform method of tillage*. Secondly, *upon*

one common quality of soil; but, thirdly, *under various conditions of manuring.* For this purpose a field was divided into a number of small plots of about three-fourths of an acre, and each became the area of different consecutive trials. From year to year the kinds and quantities of the various manures used, as well as the measure and weight of the grain produced, and the weight of the straw and chaff were accurately registered.

To afford a common standard of comparison, one of the plots was contemporaneously and successively cropped with the same kind of wheat as the others, but *without manure of any kind;* and the results also duly recorded.

The period occupied by this laborious and admirably conducted investigation, extended to no less than thirteen successive years; and as the results possess a very important bearing on the general principles of Tullian husbandry, they will, in this chapter be largely cited.

Of all of them, however, it is primarily to be remarked—

1st. That, made, as they were, irrespective of considerations of industrial profit to the experimenters, they do not fall within the category of *practical trials.*

2nd. With regard to the *cultural means used*, these were deemed of so little importance in the enquiry, that, in the reports of the trials published by the experimenters themselves, no circumstance connected with *tillage* is admitted, except only in the nugatory instance referred to in the foot note at p. 153.

And, thirdly. Although the trials consisted of instances of *unintermittent corn growing*, it is remarkable that Jethro Tull's discoveries, doctrines, and practice in that mode of husbandry were, in conducting them, completely ignored.

Thus then, the Rothamsted experimental records do neither throw, nor in their conception were they intended to throw, any direct light on the theory or practice of tillage, viewed as a fundamental element of industrial agriculture.

Proceeding now, to the particulars of these experiments, we begin with the continuously unmanured or standard plot.

"On a soil of heavy loam, on which sheep cannot be fed on turnips, four, five, and six feet above the chalk, and therefore, uninfluenced by it, except in so far as it is thereby naturally drained, ten crops of wheat have been taken in succession, *one portion always without any manure whatever*, and

the rest *with a variety of manures*, the effects of which have been carefully observed. The seed is of the red cluster variety, drilled uniformly in rows at eight inches apart, and two bushels to the acre, hand-hoed twice in spring, and kept perfectly free from weeds. When the crop is removed, the land is scarified with Bentall's skimmer, all weeds are removed, it is ploughed once, and the seed for the next crop is then drilled in. During the ten years the land, in a natural state, *without manure*, has produced a uniform average of sixteen bushels of wheat an acre, with 100 lb. of straw per bushel of wheat, the actual quantity varying with the change of seasons, between fourteen and twenty bushels. The repetition of the crop has made no diminution or change in the uniformity of the average; *and the conclusion seems to be established, that if the land is kept clean and worked at proper seasons, it is impossible to exhaust this soil below the power of producing sixteen bushels of wheat, every year.*"

Such is the admirable description of this experiment, given in the tenth year of its progress, by the author of "*English Agriculture;*" and from Table I., of this chapter, at p. 175, it will be seen that to its conclusion, in the thirteenth successive crop, there was no decrease in productive-

ness, nor any indication of exhaustion of the soil.

But what has thus been specially related of the Rothamsted soil, is, on the authority of Tull, essentially true of all soils. "A soil," he says, (meaning a soil in its natural state,) "which is proper to one sort of vegetable, once, is, in respect of the sort of food it gives, proper to it always;" and again, "the same quantity of tillage will produce the same quantity of food in the same land; and the same quantity of food will maintain the same quantity of vegetables."

"*A vineyard, if not tilled, will soon decay, even in rich ground*, as may be seen in those in France, lying intermingled as our lands do in common fields. Those lands of vines, which by reason of some law-suit depending about the property of them, or otherwise, lie a year or two untilled, produce no grapes, send out no shoots hardly; the leaves look yellow, and seem dead, in comparison of those on each side of them, which, being tilled, are full of fruit, send out a hundred times more wood, and their leaves are large and flourishing; *and continue the same annually for ages, if the plough or hoe do not neglect them.*

"No change of sorts is needful in them, *if the*

same annual quantity of tillage (which appears to provide the same annual quantity of food) be continued to the vines."

Yet, of primary importance as thus are the uses and benefits of tillage, how common is the vague and narrow conception, that the only object of working the soil is to promote the mere mechanical accommodation of plants in the exercise of their underground functions. That this is *one* of its consequences is most true, yet still more particularly is tillage to be regarded as a means of replenishing the staple with actual materials of fertility as real, although impalpable to the senses, as the distribution of court yard dung in the turnip field, or a top dressing with special manures. What else but the extra tillage of the *bare fallow* is it, which causes the, perhaps, double productiveness of the succeeding years crop? From skilfully conducted tillage it was, that Tull's fields, although bearing yearly, unmanured corn crops, increased in fertility, because the aero-manurial effects on the soil, of his very perfect system, year after year, became greater. Hence also it is, that viewing tillage as both a contributive and stimulative agent in vegetation, every soil may be said to possess its *tillage zero* of productive capability, below which

(the same amount of tillage continued) no mode of cropping can reduce it, the elevation or depression of that *zero* point being in the ratio of the amount and quality of the applied cultural operations. If of the ordinary kind, such as was used in the Rothamsted unmanured experiment, about to be tabulated, (see Table I. below) it may, speculatively be rated at from 16 to 17 bushels of wheat per acre on average soils, and on an average of years; while to Tullian husbandry (see ch. xi. Tables I. and II.) an equivalent of from 24 to 25 bushels may be assigned when performed by the *plough*, and about 34 bushels, if by *spade work*. On this subject various of the Rothamsted experiments are highly instructive, and will in the sequel be cited ; but we now present, in a condensed form, the successive yearly returns of the plot subjected to thirteen consecutive *unmanured* wheat crops. In the same Table the results also of a cognate trial conducted at Holkham, and reported by Mr. Lawes, in vol. xvi. of the *Royal Agricultural Journal*, p. 207, will also be given.

TABLE I.

SHEWING THE ACREABLE YEARLY PRODUCE OF SUCCESSIVE AND UNMANURED WHEAT-GROWING AT ROTHAMSTED AND HOLKHAM.

	DESCRIPTION OF SOIL.	CROPS OF PRIOR ROTATION.	EXPERIMENTAL CROPS IN BUSHELS. Years. 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	Average. Bns
Rothamsted.	See page 170.	Turnips Dunged.	16	23¾	17.3¾	16.3½	14.3	19.1	15.3¼	15 (?)	13.3¼	5.3¼	21.0¼	17	14.2	16.1
		Barley.														
		Peas.														
		Wheat.														
		Oats.														
Holkham.	"A light thin and rather shallow brown sand loam, but resting upon an excellent marl, containing a large quantity of calcareous matter."	Not Stated.	15.2½	21.2	16.3⅛	..	..	..	..	..	.	..	..	..	..	18
		Turnips Manured.														
		Corn.														
		Clover.														
		Wheat.														

2) 34.2

Average of the two Sets of Experiments . . . . . Bus. 17 1

Another analogous, though differently arranged, experiment on *unmanured* wheat growth, may next be cited, shewing, as it does very strikingly, what may be called the actual equivalent, in bushels of corn, of tillage of the ordinary kind bestowed on a bare fallow.

TABLE II.

	Bus. per Acre
In 1850–1, one of the Rothamsted plots was bare fallowed, and therefore produced	0
,, 1851–2, being cropped with wheat, and cultivated similarly to the continuously cropped plot, it produced.....	37
,, 1852–3, it was bare fallow, producing.....	0
,, 1853–4, being under wheat, it produced.....	42
,, 1854–5, it was bare fallow, producing.....	0
,, 1855–6, it bore crop, and yielded	21
	3) 100
	33·1
In 1851–2, the unmanured and continuously cropped plot yielded ..... 13·3	
,, 1853–4, ... 21·0	
,, 1855–6, ... 14·2	
3)49·1	
	16·2
Average superiority of the biennial crops.....	Bus. 16.3

Now, since this superiority is in the ratio of two to one, there need be no hesitation in attributing the doubled biennial yields of this

fallowed instance :—firstly, to the benefits of two years' tillage, obtained by one year's crop ; secondly, to the power of the soil to store up the unused nutritive matters, elaborated in the prior season, from all abstraction, save only by the roots of the succeeding year's crop, which, thus supplied with double aliment, yielded a double increase. Nor is it uninteresting to know, that a portion of the same plot, having in 1854–5, been divided off for separate experiment, and put under a second successive wheat crop, the produce at once dropped down to the average *zero* of sixteen and a half bushels.

The next instance of Rothamsted experiment affords an important contribution to that limited amount of precise knowledge, which exists in relation to the industrial or productive value of farm-yard dung, as a fertilizer.

TABLE III.

	Bus. per Acre
For seven successive years one of the plots was annually manured with fourteen tons of farm yard dung, and produced an acreable average of	28.0
During the same period, the *standard plot* (by which expression is henceforth to be understood the continuously cropped, and unmanured one) yielded an yearly average of...	17·3
And thus there is brought out a superiority of increase, attributable to the manure, of.....	10·1

Which, converted into money at 7s. per bushel, gives	£3	11	9
Now, assuming the cost to the farmer of producing this fertilizer, to be (as stated by Morton, in his Cyclopedia of Agriculture) 5s. per ton, and 6d. more for carting, &c., the cost of the above experimental quantity is	3	17	0
Hence, it would thus seem that not only is there no gain by the use of farm-yard manure, applied to the wheat crop, but an actual loss of	0	5	3

But further: if from this experiment it is to be inferred, that, in the growth of wheat, 10b. 1p. must be held as the productive equivalent, of 14 tons, of dung accumulated by the live stock of the farm, even when applied in yearly succession, how small must the residual benefits be conceived to be, of even this typical species of fertilizer, to the ultimate cereal member of a rotation after contributing its nourishment to the various prior crops. A similar experiment at Holkham gave almost exactly similar results; and whilst it must be admitted, that on so narrow a basis of observation, it would be premature to draw any general conclusion adverse to the economical manufacture and use of court-yard manure, it is impossible not to remember the very secondary

importance attributed to it by that greatest of agricultural observers and reasoners, Jethro Tull.

The following Table exhibits the results of an analogous experiment with Rape-cake, conducted at Holkham.

TABLE IV.

	Bus. per Acre		
Dressed yearly for three years, from 1852–54, with this substance, at the rate of 2,000 lbs. per acre, a plot yielded, on an average	31·3		
And deducting the *zero* produce of the standard plot, namely.....	17·3		
An additional yield, attributable to the manure, is shewn of	14·0		
The money value of this quantity is		£4	18 0
But as the ordinary price of rape cake, 2,000 lbs. will cost		5	11 0
There is thus exhibited a loss per acre, by the use of this substance as a fertilizer, of.....		£0	13 0

§ 2. *Of the Old Scottish System of Farming.*

These experiments in manuring, as well as the general principles involved in that department of husbandry, will receive considerable illustration from the following brief account of the Old Farming of Scotland, anterior to the introduction there, of the alternate system, in the latter part of the last century.

Of old, the Scottish farm consisted in point of area of, first, a series of fields lying more immediately around the homestead, (hence termed infield,) and these formed the main part of the farm, and as such received the farmer's chief attention; secondly, various enclosures lying exterior to the infields, and therefore named *outfield*; thirdly, of a track of moorland pasture beyond the outfields: and, fourthly, of a detached mountain cattle-range, usually under commonable occupancy. Upon this last part of the farm, the store animals were summered; and at the close of the season, these were brought to the home pasture, and there turned loose to shift for themselves, as they best could, during winter. Nightly, however, they were folded in one or other of the outfields, which, thus receiving the manurial benefit of their droppings, become in some sort able to undergo crop after crop of corn, until what between the secondary attention which the outfield tillage received, and the increase of weed consequent on imperfect management, the yield, yearly decreasing, came at last to be no more than repaid seed and labour. Arrived at this stage of depression, the field was dropt out of cultivation; and, in process of time, acquiring a spontaneous

covering of natural herbage, it then was thrown open to the beasts, and became part and parcel of the wintering pasture ground. In this state it was left to recruit itself for a number of years, greater or less, according to the quality of the soil; and then was again folded and cropped as before. In this manner were the outfields, one after another, subjected to a periodical alternation of cereal and pastoral husbandry.

Next, as respects the treatment of the *infield*. And if it be true, that to the Roman colonists of England was due the introduction of the *bare fallow* in the practice of that country, so probably the absence of that expedient from the old Scottish system may be attributable to no Roman settlement having ever been permanently formed in the northern and less accessible and inviting part of the island. Be that as it may, the bare fallow was, in fact, unpractised in Scotland until the middle of the last century, and the in-field was subjected to absolutely unintermittent corn culture, without the periodical intervention of any fallow rest whatever.

Yet it is very certain that this treatment, continued for many centuries, in no respect undermined the natural productive vigour of the soil,

since the very same inclosures, originally selected for in-field management because of their superior quality, are, still noted as the most fertile portion of the farm. Indeed, manurially considered, the system was far from unfavourable to sustained fertility in the infield, because on it was exclusively distributed the entire court-yard products, consisting not only of its own straw converted into dung, but of the fodder of the outfields also; and thus in effect, the infield was constantly receiving extraneous contributions of vegetative nutriment.

But to pursue this important subject a little farther. At last, the alternate system suddenly broke in and overwhelmed the old Scottish husbandry, subjecting both infield and outfield to one common management of regular rotations; and at this point of our narrative, the question naturally arises, What now, through this radical change, became the manurial circumstances of the farm? They may thus be defined. Much greater crops were raised from the soil; but as the quantity of produce in cattle and corn sent to market was proportionably great, what remained to be restored to the fields in the condition of manure, was, therefore, *a mere residue* of those

vegetative matters, which in the previous season had been withdrawn from the soil. In other words, a much increased expenditure of *terrestrial* nutriments was thereby occasioned, without any replacement of them from extraneous sources.

That progressive prosperity and not impoverishment signalized this seemingly exhaustive innovation would be marvellous, did we not know that tillage is stimulatively a substitute for manure; that an amazing improvement in every department of tillage characterized this change in Scottish agriculture; and specially that, at a time when Jethro Tull's principles and practice were rejected by his own country; these, to the lasting honour of Scotland, were, in drilled and horse-hoed fallow cropping, made a chief basis of her new husbandry.

"It was a singular testimony of merit," says Mr. Wren Hoskyns, writing of Tull, "that his work was translated simultaneously by three French writers, unknown to each other. But nearly thirty years elapsed before his practice was at all generally adopted or understood, and *this* (through the instrumentality of Lord Belhaven, who had the merit of introducing it into East Lothian), *took place in Scotland*, long before it was common

in England. It proceeded, however, but slowly until about the year 1762. But the whole history of Scottish agriculture from that period is as Mr. M'Culloch has remarked, of the rapid increase of its rental, from the year 1795 to 1815, " probably unmatched in any old settled country." —*Morton's Cyclopedia of Agriculture;* Introductory Essay, p. 19.

§ 2. *Of that theory of Degeneration in the cultivated cereals, which, heretofore, has usually been an objection to a departure, in practice, from the alternate system of husbandry.*

Of the validity of this once prevalent theory, Jethro Tull not only entertained no belief, but specially directed and argued against it his happily expressed thesis, " that a soil which *is proper to one sort of vegetable once, is, in respect of the sort of food it gives, proper to it always*," and which may be amplified in substance, into the following proposition, namely, that nothing in the physiological constitution of plants, either requires change of species in field husbandry, or forbids the uninterrupted yearly growth of one and the same species, on one and the same spot, if, either by nature (as

in the case of wild vegetation), or by cultivation, their roots are annually provided with a fresh supply of food, to replace that which, in the previous year's vegetation, had been consumed.

Of these propositions Tull, arguing them on general grounds, gives a variety of well-chosen illustrations. Thus, he writes :

" Pasture requires no change of herbs ; because they have annually the same supply of food from the dunging of cattle that feed on them, and from the benefit of the atmosphere.

" Meadows hold out without change of species of grass, though a crop be carried off every year; the richness of that soil, with the help of the atmosphere, dung of cattle in feeding the after-crop, or else flooding, from the overflowing of some river, some, or all of which, supply the place of the plough to a meadow.

" Woods also hold out beyond memory or tradition, without changing sorts of trees ; and this, by the leaves, and, perhaps, old wood rotting on the soil annually, which operate as a manure, because, as has been said, earth which has once passed any vessels, is so changed, that for a long time after, it does not regain its homogeneity so much as to mix with pure earth, without fermenting ; and by

the descent of the atmosphere, the trees shadowing the soil, to prevent the re-ascent of what that brings down; all this, resembling tillage, continually divides the soil, and renews the food equal to the consumption of it made by the wood.

"It is seen, that the same sort of weeds which once came naturally in a soil, if suffered to grow, will always prosper in proportion to the tillage and manure bestowed upon it, without any change. (And so are all manner of plants that have been yet tried by the new husbandry, seen to do.)"

But, citing again, the vineyard culture, "what proves this thesis most fully," says Tull, "is that where they constantly till the low vines with the plough, which is almost the same with the hoe-plough, the stems are planted about four feet asunder, chequer-wise; so that they plough them fourways. When any of these plants happen to die, new ones are immediately planted in their room, and exactly in the points or angles where the others have rotted; else, if planted out of those angles, they would stand in the way of the plough. These young vines, I say, so planted in the very graves, as it were, of their predecessors, grow, thrive, and prosper well, the soil being thus constantly tilled: and if a plum tree, or any other

plant had such tillage, it might as well succeed one of its own species, as those vines do.

"And the last argument I shall attempt to bring for confirmation of all I have advanced, is, that which proves both the truth and use of the rest, viz., that when any sort of vegetable, by the due degrees of heat and moisture it requires, is agreeable to a soil, it may, by the new horse-hoeing husbandry, be continued without ever changing the species."

Besides these beautiful illustrations, however, we are enabled, by the Rothamsted experiments, to present this subject under very severe investigation, and in a light altogether convincing to any reasonable mind, how accustomed soever to venerate the alternate system as necessary to *sustained* perfection in vegetation. But before relating the instance, the question shall primarily be raised, What, when strictly examined and disassociated from mere vulgar belief, are the characteristics and real nature of that phenomenon in vegetation which, in its true sense, is *degeneration?*

Now, taking as an example the oat plant; in Scotland, as is well known, the cultivation of this cereal has obtained very great attention, and from this cause, joined possibly with peculiar

suitableness of climate, it acquires the compact shape and remarkable thinness of husk which are usually seen in the samples of that country. But, every one knows, that if a parcel of this kind be transferred for cultivation to some less appropriate climate, and there subjected to inadequate tillage, especially if accompanied by *in and in* seeding, its characteristics of *breeding* will, year after year, gradually disappear, and the progeny ultimately acquire features of inferiority betokening a return to wild vegetation. Again, if in addition to these, any further signs of retrogression were sought for, they would be found in a diminished kernel, relatively to husk, and consequently in a decreased weight per bushel of corn, as well as, commonly if not always, a decrease in the weight of the grain relatively to that of the straw. But again, if next, this deteriorated product were re-transferred to the locality of its original parentage, and there cultivated, even then its acquired imperfections would continue to exhibit themselves, through several successive generations, with more or less hereditary persistency.

Now, if in these *qualitative* circumstances are to be recognised the true characteristics of *degeneration*, how palpably distinguishable is this phenomenon

from that one with which it is so usually and erroneously confounded, and which consists in *quantitative* not *qualitative* falling off. Thus, for instance, take the supposed case of three several farms of similar soils, occupied by three equally good farmers, and who, though each pursuing a different mode of management, severally do so with judgment and skill. Two of them follow rotation systems, the one according to those notions of high farming, which lead to a liberal expenditure in adventitious feeding stuffs and extraneous manures. The other contents himself with consuming no more than his own green crops in the courtlage, and with using nothing but the fertilizing products from that source in his fields. The *quality* of corn produced by each is the same, but the quantity greater in the first case, and less in the second. Will any one assert that in the latter instance the phenomenon of *degeneration*, in its proper acceptation, is discernible? The third farmer, disbelieving any profitable advantage in alternate husbandry, and convinced that the cost of making and applying homestead manure is more than its intrinsic worth, subjects his fields to unalternate and unmanured corn growing, and in consequence, in place of realising

30 or 40 bush. per acre from his soil, as under a four-field course of cropping may biennially be done, he gets 16 bushels *annually*. Now, remembering that the issue at the present moment under trial, is merely physiological, and is exclusive of any question of ultimate pecuniary profit, has there, in this instance, more than in the other two, been disclosed any element of true degeneracy? If, in short, we are to seek for a real criterion of that vegetative phenomenon, must it not be in *qualitative* not in quantitative circumstances?

But the question, perhaps, will next be raised by doubting minds, whether true *qualitative* degeneration is not, actually, an invariable consequence of unintermittent cereal cultivation. Now, in proof to the contrary there is, in the first place, the old unalternate husbandry of England to shew that century after century the grain productiveness of the country was eminently progressive (see Table I. p. 30). Passing next to particular cases, we have Tull's reiterated assurances that improved quality of corn was a notable characteristic of his unalternate system. Moreover the circumstance recorded by him, that under that management the ratio of weight between the corn and straw of his sheaves became greater in favour of the former, is in itself

conclusive on this subject. In the subsequent instances of Tullian husbandry, cited in Chapter xi., Tables I & II, the only data on this point, are the proportions stated in five of them (Nos. 7, 8, 9, 10 & 11) of the weight of straw compared with the quantity of corn ; and as the ratio on an average of all these cases is under 8 cwt. of the former to each quarter of the latter, they are hence to be held as indicative of a well conditioned produce in every respect. But further, in those invaluable reports of Rothamsted investigation, which form the main subject of comment in this Chapter, the weights of both corn and straw were yearly recorded, and these are accordingly made the foundation of the following Table :

TABLE V.

	Bushels per Acre.	Weight of Grain per Bushel.	Total Weight of the Bushels per Acre.	Weight of Straw per Acre.
1. In order to form a standard of comparison, the estimated acreable produce of wheat and straw, given in the instance already cited from Bayldon's work, at p. 157, shall be taken, viz. .. NOTE.—No weight per bushel is given in that estimate, but it is here assumed at 63lbs.	Bush. 32	lbs. oz. 63 ?	lbs. oz. 2016	lbs. oz. 3360
2. Average produce of seven years of the Rothamsted plot manured with farm-yard dung	28	64.8	1809	2966
3. Average produce of the standard plot for the same period	17.3	63.6	1125	1756
In the similar trial at Holkham the results were as follows :—				
1. Proceeds of the plot manured with farm-yard dung	30 ½	62.10	1910	2606
2. Proceeds of the plot manured with rape cake	31. ¾	61.3	1941	2747
3. Produce of the standard plot	17. ¼	61.4	1086	1298

NOTE.—The less proportion of straw in these latter instances, compared with the Rothamsted trials, arises from the chaff and cavings having been excluded from the weighing of the straw.

If, now, the truth of the hypothesis, which assigns to successive corn growing a degenerative effect (using the term in its proper qualitative sense) be assumed for a moment it would, *a priori*, be inferible, that were calculations gone into of

the comparative weight of corn and straw in these alternate and unalternate instances, they would pronounce in favour of the alternate system.

But, in point of fact, such calculations actually made, give no countenance either to this inference or to the unreal hypothesis from which it is drawn,—as is seen from the following Table :—

TABLE VI.

	Weight of Grain per Bushel.	Weight of Straw for each lb. of Grain.
ROTHAMSTED EXPERIMENTS.		
	lbs. oz.	lbs. oz.
1. Instance cited from Bayldon's work	63.	1.10
2. Rothamsted plot manured with farm-yard dung	64. 8	1.10
3. Rothamstead standard unmanured plot...	63. 6	1. 9
HOLKHAM EXPERIMENTS.		
1. Plot manured with farm-yard dung	62.10	1. 5
2. Plot manured with rape cake	61. 3	1. 6
3. Standard unmanured plot	61. 4	1. 3

To pursue this argument any further, would simply be to maintain a profitless conflict with a convicted vulgar error. *Degeneration may indeed be*

a concomitant of imperfect tillage, but is not necessarily produced by either unalternate or unmanured corn husbandry.

§ 3. *Of the Theory of "Nitrogenous Manuring," as contradistinguished from the "Mineral Theory" of Liebig.*

In all countries there are very fruitful soils, of which the origin may be traced to the natural disintegration of the underlying rock; and if a lump of such rock were reduced by trituration to the fineness of mould, it might be used experimentally as an artificial soil.

Suppose, then, a flower-pot to be filled with a preparation of this kind, and a seed of some ordinary plant to be deposited therein, and the apparatus placed in the open air to obtain all the atmospheric influences which vegetation, in its common condition, receives. So arranged, the seed would germinate, and the plant grow and fructify, if not with all the exuberance, at least with all the essential perfectness of one growing in a cultivated field.

If, however, another seed of the same kind were deposited in a similar apparatus filled with the prepared rock,—and so placed as not to receive

the benefits of rain-fall, but to be moistened instead with water deprived, by distillation, of all atmospheric impregnation; the plant so treated would indeed grow, but neither vigorously nor fruitfully.

To account for this difference, the explanations given in a prior chap. (ch. vi. p. 59) require only to be remembered; namely, that rain-drops and dew in their descent through the air, absorb into themselves, by solution, the atmospheric constituents of plant fertility, of which nitrogenous compounds form essential elements, and these saturating the artificial soil of the first of these two experimental instances, and performing both contributive and decompositive functions favourable to vegetative action, elaborate thereby an amount of joint mineral and atmospheric aliment adequate to the nurture of the perfect plant; whilst these conditions being absent in the second case, an abortive development of growth is the consequence.

Next, let several such experimental vessels be charged with the same material. Let it also be supposed, that the constituents, terrestrial and atmospheric, of the species of plant to be grown in them, have been ascertained by chemical

analysis, quantitatively as well as qualitatively, and that three separate quantities of water are prepared with the following solutions:—one with the ascertained proportion of *mineral* substances in the plant; another with the proportion of its *atmospheric* ingredients; and the third with a mixture of *both*. If now by watering a pot with each mixture separately and exclusively, the experimenter should find that, although all the three obtained benefit from the process, the two treated with the atmospheric impregnations produced a more vigorous and more fruitful plant than that moistened with the mineral prescription; if further he found in other trials that the efficacy of the atmospheric solutions was always greater where an extra proportion of *nitrogenous* ingredient was used, then might he be entitled, theoretically at least, to maintain, that where adventitious development is sought to be attained in vegetation by means of artificially applied nutriments, a *nitrogenous* element should be made to preponderate in the prescription.

Further still; if results like these were unequivocally brought out, by analogous trials of various nitrogenous manures in field experiments,

what, till then, were, perhaps, to be regarded as speculative conclusions only, might now merit the character of practical demonstration; and these being, in reality, the circumstances which characterised the Rothamsted trials, instituted to test this important question, the teaching of that school of agricultural investigation is, in England at least, regarded as forming the basis of the nitrogenous side of the theory of specific manuring, and as exhibiting all that is yet known of the manner and measure of its practical efficacy and economy. Accordingly, in Table VII. of this chapter will be found a succinct abstract of certain of these experiments, as well as of certain industrial calculations founded on them.

Next, to resume from page 166, the leading principles of the "Mineral Theory."

It has already been assumed, that the constituent chemical elements of the experimental plant have been ascertained, both quantitatively and qualitatively. Let it next be assumed that the artificial soil in which it grew has also been analyzed. Now the previous fact that the plant had actually thriven in it, of itself, is good evidence that at least all the mineral elements of

vegetative growth were in the detritus; and actual analysis would afford the same conclusion.

Conceivable it now must be, that were one plant after another to be grown yearly, in one and the same experimental pot for a number of years, the quantity of vegetative nutriment contained therein, would necessarily undergo an amount of diminution, quantitatively as well as qualitatively, equal to what mineral pabulum had been consumed by each yearly plant in its growth and fructification. If further, in another pot, a more luxuriant plant were raised, by means, we shall say, of a maximum application of nitrogenous stimulant, it is also obvious that the amount of mineral abstraction would, in that case, be correspondingly greater.*

* Take any vegetable at maturity, say a ripened wheat plant with the grain in the ear, and weight it. Expose it, next, for a considerable time to a heat short of scorching, and again weight it. A loss of weight will thus be caused occasioned by the expulsion by evaporation of all the free water in the plant. Next, let the plant be burned in an open vessel, carefully, so as to preserve what ash remains after the combustion has ceased; weigh the ash, and its weight gives the precise amount quantitavely of *terrestrial* nutriment withdrawn from the soil, in the growth and fructification of the plant, through the medium of the roots. The difference of weight between the dried plant and the

Assuming next, both pots to contain equal amounts of nutriment, and the rate of withdrawal to be double in the second instance, of that in the first, then of course the ultimate reduction of the soil to the state of *caput mortuum* would occur in half the time. Hence the economic effect of nitrogenous or any other kind of merely stimulative manuring, examined as an industrial question, is not to confer additional productive power to the soil, but only to stimulate its normal capacity in that respect, to more rapid exertion, at the expense of more speedy ultimate exhaustion. In this way, the only element of difference between the two cases, is that of *time* only.

But, "in agriculture," says Liebig, "no factor, or element of the calculation, is more important

ash, indicates the amount of *atmospheric* food assimilated by it from the soil and air by means of the roots and leaves.

Estimating the mean produce of an acre of wheat corn, and straw, at lbs. 4,500

The proportions of *aqueous*, *atmospheric* and *terrestrial* constituency in this quantity, may approximately be stated thus :—

Water	lbs. 563	
Atmospheric matter	3759	
Terrestrial matter	178	
	——	4,500

than that of time; and the too great neglect of this consideration in farming is unquestionably the most serious obstacle to its progress. The just appreciation of the value of any special manure depends on a knowledge of its effects in *time*. An individual manure, which, in one year, may increase the produce of a field, in the most astonishing manner, may, if applied to the same field in the same way for five years, produce not the slightest effect, or even a diminution of the produce. Hence arises, when the manure is used for a short time, an over-estimate of its value, and in a longer period, an unmerited depreciation of it.—*Royal Agricultural Journal*, vol. xvii. p. 297. The very same industrial consideration is expressed by Tull in a passage already quoted at p. 51. "Dung, without tillage, can do very little; with some tillage does something; with much tillage pulverizes [*i. e.* fertilizes] the soil *in less time* than tillage alone can do; but the tillage alone, *with more time*, can pulverize [fertilize] as well."

From the foregoing ideal illustrations, the transition is not difficult to the manurial practices of actual farming; and concerning these, the following may be held to be the substance of Liebig's opinions, so far as it necessary to cite them in addi-

dition to what already has been stated at p. 166, viz. :—First, that the natural processes in the soil by which vegetative mineral nutriment is constantly produced, are susceptible of two kinds of cultural increase, *one* resulting in a moderate but permanent elimination of fertility ; *the other* in a present excessive productive action, followed sooner or later by a corresponding degree of exhaustion. Secondly : That to the former of these processes belongs every manurial means which promotes the restoration quantitatively and qualitatively to the soil of the terrestrial aliments, removed from thence in the crops. Thirdly : That to the latter system belongs the use of nitrogenous manures ; and Fourthly, that when the farmer in sending to market the extracted mineral essence of his fields in the form of corn and meat, fails to bring back manurial matters, rich in the terrestrial elements of vegetation so alienated—and when, instead, he loads his return waggon with stimulants, whether nitrogenous or of any other kind, in order, in the succeeding season, to excite an inordinate productiveness, he is like the reckless spend-thrift, who, not content with the yearly income of his fortune, persistently encroaches on the capital,

and ends in poverty; or to change the simile, the judicious manuring farmer is like the prudent manufacturer, who is constantly making due provision of raw material, both in kind and quantity, proportioned to the amount of goods he purposes to work up and send to market.

To expatiate further on these conflicting Theories would be beyond the scope of this treatise; and there shall now be placed before the reader a Table composed of Rothamsted experiments made with special manures of the ammoniacal kind, and in which will be found a succinct exposition, both of the quality and quantity of the substances used, and of the productive returns and economic results so obtained.

TABLE VII.

SHEWING THE PARTICULARS OF THE ROTHAMSTED EXPERIMENTS IN AMMONIACAL MANURING; AS REPORTED IN VOLS. XII. AND XVI. OF THE *Royal Agricultural Journal of England.*

Year.	No. of Plots.	MANURES. Sulphate of Ammonia.	MANURES. Muriate of Ammonia.	PRODUCE. Dressed Corn.	PRODUCE. Total Weight of Corn.	PRODUCE. Weight of Straw.	PRODUCE. Weight of Total Produce
		Lbs.	Lbs.	Bush.	Lbs.	Lbs.	Lbs.
1845	No. 9.	168	168	33.1½	2131	4058	
1847	„ 9*a*?	150	150	26.2	?	?	?
„	„ 9*b*	150	150	26.–	?	?	?
1845	„ 10*a*	168	168	31.3¼	1980	4266	6246
1846		224	„	27.1½	1850	2244	4094
1847		150	150	25.3	1702	2891	4593
1848		150	150	19.1	1334	2367	3701
1849		200	200	32.2	2141	2854	4992
1850		200	200	26.3½	1721	3089	4810
1851		?	?	?	?	?	5036
1852		?	?	?	?	?	4107
1853		?	?	?	?	?	2691
1854		?	?	?	?	?	5808
1855		?	?	?	?	?	3797
1845	„ 10*b*	168	168	31.3¼	1980	4266	6246
1847		150	150	25.2¾	1705	2874	4579
1849		200	200	32.2¾	2156	2964	5117
1851		?	?	?	?	?	4985
1852		?	?	?	?	?	4162
1853		?	?	?	?	?	3578
1854		?	?	?	?	?	7003
1855		?	?	?	?	?	5073
Averages..		173	154	28.1	1558	2656	4769

Average of dressed corn brought forward... ...*B.*		28.1
In the years in which the Produce of Dressed Corn is specified in the foregoing Table, the average produce of the unmanured standard plot was...		17.3¾
Average acreable increase by means of the manures		10.1¼
Which, at 7s. per bushel, is equal to		£3 12 1
The acreable cost of the manures is as follows:—		
Sulphate of Ammonia, 173lbs. at £15 per ton.	£1 3 0	
Muriate of Ammonia, 154lbs. at £26 per ton.	1 15 0	
		2 18 0
Gain per acre from the use of Ammoniacal Manures in successive wheat growing		0 14 1

But while ammonia gives growth, "it depends," says the author of *English Agriculture*, in commenting on the Rothamsted experiments, "on *climate*, whether that produce is *straw* or *corn*. In a wet, cold summer, a heavy application of ammonia produces an undue developement of the circulating condition of the plant, the crop is laid, and the farmer's hopes disappointed."—*English Agriculture*, p. 461. This is that "unhealthy grossness of wheat fed with crude ammoniacal salts" alluded to by Mr. Way, when expressing the proposition, that "wheat grown after the

Tullian system seems never to become over luxuriant; for, in the latter case, as the ammonia is only obtained by virtue of the power of the soil to abstract it from the air, so it can never exist in it in any other than the form in which it is best suited for the wants of the crop."—*Journal Royl. Agricl. Soc.*, vol. xiii. p. 143.

Thus, at every turn, do we find modern science paying obeisance to the comprehensive and eminently practical genius of JETHRO TULL.

CHAPTER XIII.

Recapitulation and Summary.—Young's Eulogy on Tull.

In this concluding chapter, we would recapitulate what in the foregoing narrative it has been our endeavour to shew:

First: That Jethro Tull was the originator of thin sowing in English agriculture.

Secondly: That he was the inventor also, not only of every species of drilling, whether in corn or fallow crops, now practised in modern husbandry, but of the first English drill sowing machine.

Thirdly: That to him likewise we owe the introduction of that kind of interculture peculiar to the fallow crops, and which, in times past, has been the great ornament and main success of alternate farming.

Fourthly: That the doctrines, *Tillage a substitute for manure*, and *Tillage competent to support unintermittent corn growing*, although hitherto rejected in modern farming, were also taught and practised by him.

Fifthly: That to exclude the cultivation of cattle crops from the management of the modern improved farm, would only be to revert to the ancient tillage farming of England, which obtained up to the introduction of roots and clover as plants of field culture.

Sixthly: That this elder husbandry was vicious in no respect except in an insufficiency of tillage means, either to cleanse the surface from foul vegetation, or to promote adequately the mechanical and chemical amelioration of the staple.

Seventhly: That the main feature in the old tillage husbandry of England was successive corn growing, under which, successive as it was, the soil of the kingdom, not only underwent no diminution in productiveness, but actually kept pace in fertility with the advance of national industry, and the improvement of agricultural practice. It was also pointed out, that this increasing fruitfulness could not be attributed to manuring, except in the least degree, because, in fact, this expedient, so far as corn growing was concerned, was practised *in minimo*.

Eighthly: That Jethro Tull's method of unintermittent corn growing, without manure, was simply a reformed adaptation of the old hus-

bandry; and that in the actual practice of that method, he proved the truth of the following propositions, viz. that the then newly originated theory of change of species being a necessity in field culture, was a fallacy, since his own crops instead of falling off became yearly more abundant; that not only was his mode of working the land a substitute for manure, but more than a substitute for *old* manuring, since increasing fertility was the consequence; and that in point of economy of labour, as well as efficiency of performance, his tillage procedure was every way successful.

Ninthly: That while Tull's system of tillage is, as a general scheme, to be regarded as a substitute for manure, it in nowise precludes the use of fertilizers, stimulative or contributive, in aid of tillage, where considerations of profit point to their use.

Tenthly: Referably to instances in Tullian culture, subsequent to Tull's time, we have submitted a number of experimental cases, of which, it may be said, that without extending our knowledge beyond what Tull had already taught and practised on a larger scale, they confirm the catholicity, practicability, and profitableness of Tullian corn husbandry.

It cannot be, however, that the ENGLISH FARMER will longer leave the momentous problem involved in these propositions to be solved by amateur experiment; nor less impossible is it to conceive that LANDLORD and AGENT will be backward to encourage and even stimulate every reasonable attempt on the Tenant's part to determine whether Tull's cereal system may or may not be profitably engrafted on modern agriculture. To be convinced that the present forms of Alternate Husbandry are pregnant with danger, it is only necessary to peruse with attention the report of a recent most important discussion in the *Central Farmers' Club*, in which wide spreading degeneration of *the real qualitative type*, in barley as well as clover and turnips, is unequivocally asserted on the most conclusive evidence. See extracts, No. II. of the Appendix. In the Appendix will likewise be found quotations from a beautifully written article, inculcating a modified adoption of Tullian corn husbandry, and conceived in the true spirit of Tullian science and practice. Its author is believed to be Mr. J. A. Clarke, whose experiment forms No. 7 of the Table at p. 152.

In conclusion, it has also been seen, that amongst the many early opponents of Tull's teachings, both as to what has since been received into practice, and as to what, without trial, has hitherto been refused admission, none were more zealous or influential than ARTHUR YOUNG. But Young's fate it was, in the course of a long and eminently useful life of nearly eighty years,* to see thin sowing, drilling, and fallow culture, all on Tull's principles, introduced into the practice of every enlightened farmer in England and Scotland.

Who, therefore, will not admire the generous spirit of candour which prompted Young in the noonday of his own celebrity, to pour forth at Tull's shrine, the following eloquent and just panegyric on departed genius. "I took an opportunity," says he, in relating one of his agricultural tours through the provinces, in 1794, "to go to Prosperous farm, once the estate and residence of Jethro Tull, which he has rendered for ever famous by a work that will unquestionably carry his name to the latest posterity. Here it was that he practised and registered that drill-culture, which has been the origin of so many

* He was born in 1741, and died on February 20, 1820.

experiments, and the basis of so many publications in almost every language in Europe. It came, on his death, to his son John Tull, who, dissipating the inheritance, sold it, and died without leaving any representative to continue the name and family of a man that had rendered himself so interesting to multitudes. That he was a real genius cannot be doubted. Though drilling *in idea* was known before he was born, and a drill plough invented, yet there are no registers of any practice published to enable us positively to conclude that it was executed in any extent; and in all probability Tull knew not of those drills, and fairly *invented* his. He not only did this, but carried the husbandry into full practice upon this farm of Prosperous to the extent of 120 acres of wheat for the last two or three years of his farming; and drilled thirteen [wheat] crops in succession. It is a question whether his mode ever received any material improvements after his death, and whether any other person ever practised it with a success equal to his, which are an extraordinary proof, not of talents only, but of perseverance and firmness of resolution; and he did this under the pressure of most painful diseases, which confined him much to his

house. Every part of his works manifests strong talents and no inconsiderable learning; and he has left a name in the world which probably will last as long as the globe we inhabit."—*Annals of Agriculture*, Vol. xxiii. p. 172.

This great benefactor of mankind died on the 21st of March, 1741; and assuming his age to have been thirty-five when in 1701, (ten years after leaving the bar,) he went abroad, he thus must have borne up against his acute sufferings, for more than three score years and ten. An author of the last century, happily termed him "THAT VENERABLE HUSBANDMAN, JETHRO TULL."

APPENDIX No. I.

EXTRACT FROM AN ARTICLE ON TULLIAN HUSBANDRY, ENTITLED "*Lois Weedon, without the Spade,*" *in Vol.* xiii. *of* THE FARMER'S JOURNAL, 1858, *p.* 386.

[IT may preliminarily be explained, that the author of this excellent paper, in the first place, takes for illustration the case of a tillage-farm of three hundred acres arable, worked by fourteen horses, and cropped under a five-course rotation, giving yearly the following proportions of crop :—

	ACRES.
Winter wheat	60
Spring ditto	30
	—90
Barley or Oats	30
Pulse and Potatoes	60
	—90
Roots or Fallow	60
Clover	60
	300

And, secondly, in order to demonstrate the practicability, and probable advantage, of subjecting a considerable portion, at least, of the area of improved farms to successive wheat growing, on Tull's system, he proposes that, for this purpose, two-fifths of the farm, tabulated above, (*i.e.*, one hundred and twenty acres,) should be withdrawn from alternate husbandry, leaving the other three-fifths (one hundred and eighty acres) to be managed as before. Thus :—

UNDER TULLIAN TILLAGE.		
		ACRES.
Winter Wheat		120
UNDER COMMON TILLAGE.		
Winter Wheat	36	
Spring ditto	18	
	54	
Barley or Oats	18	
		— 72
Pulse and Potatoes	36	
Roots or Fallow	36	
		— 72
Clover		36
		300

What follows is in this accomplished agriculturist's own words.]

"Were we to farm" he says, "on the Lois Weedon principle, having two-fifths of our land in three-row wheat, we should have the remaining three-fifths under suitable green crops and spring corn; but, for the sake of avoiding calculations as to the apportionment of labour at different seasons among the crops in such a new order of succession or rotation, we suppose the three-fifths to be managed precisely as though it were a farm to itself under the present husbandry. These 180 acres would have two-fifths—that is, 72 acres—wheat, &c., ploughed for, as at present, requiring eighteen or twenty days' work of the fourteen horses. Our total seedtime will be altogether ten or twelve days longer than before;* against which we must remember that there will be less of other work than formerly, owing to the diminished area of the other varieties of cropping.

"During the latter part of October, November, and December—beginning directly the young wheat is well up, and taking advantage of periods of dry weather—the deep-working of the fallow intervals must be done. We find that one set of five horses effects this on 10 acres in the course of two

* Working and sowing 120 acres under Tullian husbandry ..				34 days.
„	„	72	„ „ common	20 „
		192		
Total time required to work and sow 192 acres yearly, in corn, under the proposed mixed system				54 „
Working and sowing, in the common manner, the 120 acres, which would, yearly, be in corn under the rotation system first tabulated....				42 „
Longer time required by the proposed mixed system				12 „

days; consequently two sets, or ten horses out of our fourteen, would finish the 120 acres in twelve days. The principal tillage operation on the other portions of the farm that would be a little delayed in consequence is only the ploughing of 72 acres of stubble for pulse cropping or for fallow.

"As we shall see when we come to describe our process, only half of each interval is subsoiled the first time; and in January and February, or directly suitable weather follows the snow and frost, the same amount of horse-labour is required to complete the deep tillage which we adopt in place of digging. This latter twelve days' work for two-thirds of our horses comes just at the time when spring corn has to be sown; but bear in mind that we have 14 horses, the full allowance for 300 acres arable, while (owing to the permanent setting apart of two-fifths of the farm for Lois Weedon wheat) the breadth of spring cropping is only that proper to a 180 acre farm—that is, three-fifths of the extent which would be grown were the whole 300 acres in rotation. Instead of 90 acres of beans and peas, oats, and barley or potatoes, there will be only 54 acres; and the time saved by having 36 acres less to get in, will go far towards sparing the teams for the second subsoiling of our wheat.

"Tolerably dry weather being a necessary preliminary to each of these operations, not only for the purpose of effectively breaking-up the subsoil, but also to avoid "maulding" the wheat-rows and puddling the surface with the horses' feet; it may be objected that the weather will preclude our deep tillage, except in a remarkably dry season. We have had only two winters' experience; the present one unprecedented for absence of downfall and scantiness of water

in ponds, wells, and drains. But in November, 1856, our first operation was stopped by rain and then snow, after half-a-day's work; in December it was completed, though needlessly done when the ground was too wet. The second operation was performed in February, and this note was made at the time—"Several fine days before, on which the work might have been done; and if postponed, there were still several more fine drys which would have given an opportunity." This last winter the first operation was well done in December after prolonged dry weather, and the second was done in February after many days in which the soil would have broken up equally well, and succeeded by plenty of bright open weather. Supposing a heavy fall of rain to follow the wheat-seeding and snow-blasts to occur, with other weather unsuitable to the drying of the ground, there would necessarily be a delay in accomplishing the tillage; but as it is during a frost that the exposure of the subsoil is most desirable, we can very well wait until any "great wets" are over. We shall have the range of at least two-and-a-half months in which to get our first twelve days' work, though on an average half the number of days in these months are more or less "rainy;" and our second twelve days' work must be caught during January and February when the weather is not at all more propitious.

"Rolling the wheat in March will take up very little of the horse-power of the farm. Scarifying the fallow intervals in April or May occupies three horses for two days in doing our 10 acres, so that two sets of three each would finish 120 acres in twelve days, or twelve horses (working four implements) in six days. This will not much interfere with the fallowing and other business going on upon the 180 acres.

"Horse-hoeing the intervals in May, again in June, or whenever required, will be a short matter; for one horse finishes our 10 acres within one and three-quarter days, consequently four horses would hoe 120 acres in about five days.

"Hand-hoeing and weeding the wheat stripes may be reckoned upon as demanding about the same labour as a similar number of acres on the common system, the wider spaces favouring the annual weeds, though there is less ground to be gone over. Employing a horse-hoe would, of course, diminish both labour and expense.

"In yoking the horses so as not to trample the wheat, in adjusting the scarifier so as to avoid casting clods upon the plants on each side, in arranging the reaping of such narrow strips of awkwardly-standing corn, there are little exercises of judgment called for; but our own experience proves that the whole management from beginning to end, is so simple that any good labourer engaged throughout one year may understand and properly execute the operations of the next.

"For carrying off heaps of rubbish that may be raked or picked, and also for leading on manurial top dressings, &c., a "quarter cart" is necessary—that is, a cart with shafts fixed in front of one wheel, so that the horse "quarters," walking in the same track as the wheel, thus making a road of the "intervals" only. And for rolling the wheat rows or fallow intervals, as the case may be, it is requisite to have a roller made in two short pieces, arranged on one axle, but with a distance between them, the shafts being removable, in order that the horses (in length) may walk either in the middle or before one of the rollers, as required. Only these two new implements need be constructed for our Lois Weedon wheat-

growing, the ordinary plough, subsoiler, scarifier, horse-hoe, ridge-harrow, and drill, answering every other purpose.

"Still further, as to the practicability of growing 120 acres of wheat, on the stripe system, upon a farm having 300 acres arable, it may be observed that the proposed mode of culture effectually provides for the eradication of couch and other creeping or perennial roots. Bunches of couch, docks thistles, &c., may be dug out of the stubble after harvest, or from the rows of the growing crop; and the fallow intervals (embracing just half of the land) are stirred, pulverized, and the root-weeds picked off. But should the surface become thoroughly infested, in spite of all, the foulness may be extirpated after harvest, by paring and scarifying the whole breadth of the land, and harrowing lengthwise and crosswise too; obliterating the stubble-rows, it is true, and so taking away the guide-marks for the next drilling, but not preventing us (as we shall see) from hitting the right intervals, with our method of gauging the drill-row distances. But, seeing that each portion of the ground is summer or bare fallowed every other year, no apprehension need arise of overmastery by ill weeds.

"One minor difficulty we have not yet removed—headlands at both ends of a field are indispensable, for the horses and implements to turn on, in the winter, spring, and summer tillage; and no vegetable seems to covet the frequent rough usage of such a situation. Are we to try for a few stray ears of wheat, or plant potatoes with a coating of manure? leave the headlands to themselves, with the exception of cutting up weeds? or lay them down to permanent seeds?"

The author having thus expounded the general principles of his plan, next goes into the following operative details.

"First, then, we would say, believe in the principle: rely upon the fact that tilling the fallow intervals does really nourish and augment the growth and produce of the wheat. For if uncertain on this point, you are sure to select a field for trial in too high a condition; the result being an early over-luxuriance and final failure of the first year's crop. Land in condition for producing a heavy crop of wheat on the ordinary plan (as, for instance, a bare fallow, a field of roots highly manured, a bean or pea stubble, or a piece of seeds richly dressed with dung or sheep-feeding) is too good to begin upon. Rather choose an oat stubble, perhaps a barley or even a wheat stubble—depending upon the known nature of your soil, and its being in or out of "heart."

"Also, make up your mind to sow earlier than you would any other wheat, because there are less than half the common number of rows on an acre; which with the same quantity of seed in each row, makes a very thin seeding, and of course more than double the usual average space between, plant and plant—a condition of things likely to end in mildew unless you sow early to prevent it. And besides, the great distances apart promote the stooling or tillering of the plants, the branching of the root, and shooting up of additional stems (which, indeed, forms one of the secrets of a good crop), and you will lose both in quantity and quality of corn unless time be allowed for this process to transpire before the advanced spring. So the preparation must take place very soon after harvest.

"Well, the "shack" being eaten off by sheep and pigs, and the stubble (if after a straw crop) carried away, of course you will autumn-clean thoroughly; forking out couch, if the land be only slightly tainted; but, most probably, skimming,

cross-cultivating, and raking off weeds and rubbish. Plough say one inch deeper than usual, in order to bring up 100 tons of fresh long-undisturbed subsoil, to supply the crop with mineral nutriment during the first year. Level and pulverize with the harrow and roll; carefully pick all root-weeds; and then comes the drilling. But mind one particular point. "Plough dry and sow wet," as Mr. Smith says: that is, do all your paring and ploughing, or ploughing followed by scuffling, or whatever order of cleaning you adopt, when the land is dry; and wait for rain to make a moist seed-bed, before you harrow fine and drill. Getting-in wheat well is always a great advantage; but is of far more consequence, one would think, when there is no store of manure in the soil to make up for defective tillage, and the preparation and treatment of the earth itself is to be the sole support of the crop. Therefore, be nice about the moisture as well as the fine tilth of the ground into which you deposit the seed; and take especial care to cut-in deeply enough with your drill coulters. A remark as to the desirability of having a fine description of seed ("red") for the sake of a bright silica-shielded straw, unless in a district famous for white wheats without mildew, and the caution of well liming, brining, or dressing with arsenic or vitriol—according to your custom—need not be addressed to men of business.

"Now for the sowing. There is to be a stripe of three rows at every five feet; the "spaces" between the rows being 10 inches each, (instead of Mr. Smith's "foot"), and the "interval" between the stripes, therefore, 40 inches. You want neither the slow line and dibble, nor a sort of parallel rule wheel "marker" purposely constructed; for a good 5 or 6-feet corn drill, either with a "steerage," or with a "swing"

coulter-bar and a good man for "leader," can accomplish the feat. Arrange four coulters on the drill thus: two at 60 inches apart, and, within these, two more at 40 inches apart; making the distances in this order, 10 inches, 40 inches, and 10 inches. Each outside coulter will make the middle row in a stripe of three; and the inner coulters will sow the rows next the fallow interval, the horses (in length) walking along this space left midway of the drill. When arrived at the end, the drill is to turn short, the outside coulter returning in its own track; and the seed is shut off from the pipe of that outside coulter next the unsown part of the field, so that the outside coulters act alternately as "markers" and sowing-coulters. In this way, the drill marks out its own work, without any difficulty after the first course—which the drill-leader "draws" by simple eyesight. Whatever swervings or bends may occur, the width of the interval to be cultivated is always invariable.

"The next year's crop will have to be sown along the intervals between the stubble-strips; and the same mode of drilling will suffice, provided the stubble rows remain visible, at least in some parts of the field. How then, do we manage to autumn-clean the ground?

"Having harrowed up the thickest of the stubble (which must be left very short by the reapers), stir the fallow intervals with Bentall's, Coleman's, or some other scarifier set as narrow as required; and harrow them two at a time, by means of two out of a "set" of three harrows—that is, the middle one removed, so as to miss the stubble space. Rolling may be done over the whole surface; or a roller made on purpose, in two short lengths with a space between, may be employed. The stubble being pretty plainly seen,

is a sufficient guide-mark for the drillmen, who cannot get far wrong when the first stroke has been taken in the right place, and if the land is in a fine state and dark with moisture. The seed may be harrowed-in with harrows covering all the ground. Should the stubble stripes be peculiarly free of couch, perhaps forking out the tufts may suffice: but we must be prepared for cleansing them when foul; and therefore have contrived how to pare or scarify them without interfering with the drilling. When the drill has begun to work, *follow it* with the broadsharer set only about 22 inches wide—not in the track of the drill, of course; but breaking up the stubble lines between the intervals just sown. We find that this operation does not displace or root-up the seed; and after it any amount of harrowing and rolling, lengthwise and crosswise, may loosen and shake out the root-weeds, without fear for the wheat in tolerably dry weather. Only this must be done before the grains have chitted; or, at any rate, before the germs reach the surface.

"The quantity of seed per acre depends, like the time of sowing, upon whereabouts you farm: being regulated by the quality of your soil, its altitude and aspect, its tendency as to weeds, its liability to worms and slugs, the peculiarities of your climate, the character of the particular season you may have, even the proximity of your holding to harbours of birds and vermin. What is early in one situation, may not be so in another; what is thin seeding in one neighbourhood, is thought thick in another. As an example, take our own case: November being the great wheat-sowing month with us, our present crop was got in the first week of October. In ordinary husbandry we drill 6 to 10 pecks per acre, the former quantity at the beginning of the season, when every

kernel will have a chance; gradually increasing the amount as the period of sowing gets later: at the same time putting in more on poor than on rich land. Mr. Smith tried only 1 peck, but "for safety and the sake of the sample," now uses 2 pecks an acre. Our tillage being less perfect than his, and the plants lying open to greater injury from horses' treading, &c., we deemed it best to drill 3 pecks per acre. This appears but a small quantity; yet Mr. Smith's experience with a thicker seeding has shown that the stalks are too many and weak to bear up their bulky heads erect. And consider, that as the average distance between our rows (taken over the entire field), is 20 inches, we have less than half the number of rows that common 9-inch drilling gives us; and thus our 3 pecks an acre puts as much seed in every single row as about 7 pecks does in plain drilling. In fact, we drill with the same cog-wheel on the cup-barrel for both cases.

"When your wheat is well up, and the triple-row emerald stripes are beautiful from end to end, comes the first really Tullian operation, namely, the ploughing along the 40 inch intervals. With a common plough, and horses "in length" (a boy leading the first horse), plough a single furrow down each interval, going, say 4 inches deep. Aiming to keep the coulter 6 inches from the wheat-row on his left-hand side, the ploughman has no difficulty in taking his furrow within 4 to 7 inches of the wheat, a latitude of deviation from the true line that must be allowed him; and the upturned slice has just room to fall over, short of the wheat on the opposite side of the interval. Very few clods will be found to roll and bury the young plant.

"Break up the bottom of every furrow with a proper

subsoil, penetrating 5 or 6 inches, according to the strength of your team. We use Bentall's broad-sharer with the side beams removed, a 6-inch share on the heel, and subsoil point in front, this going at least 5 inches down with 3 horses. The total depth below the surface is thus 9 or 10 inches. When the same intervals come under operation again (that is, in two years time), we may perhaps work still deeper, and it may be with a double-tined instead of single subsoiler. The horses, of course, are all harnessed in length, walking upon the furrow bottom.

"Leave the field thus treated (looking lengthwise like a wheat crop, and crosswise like a trenched-up fallow, reminding me of those corrugated pictures presenting two views at different angles), and let the frost and snow, wind, rain, and drying sunshine exert their forces upon it. And observe how large an extent of superfices is exposed; for not only can the atmosphere enter 9 inches down into the subsoil, but the furrow-slices thrown up at an angle, almost double the area of surface in the intervals.

"In January and February, taking the chance of suitable weather, the same tillage is to be repeated, only on the other side of each interval. The plough turns back the pulverulent furrow slice of the former operation, covering over the long exposed broken subsoil in the old furrow, and going four inches deep below the surface level, casts up upon the top a new slice of stiff unmellowed soil for the weather to act upon as before. The horses are obliged to walk along the old furrow, treading down the crumbled subsoil; but (as it has become so friable,) not inflicting much damage by compression. The newly-opened furrow must be subsoiled as before, and left in this exposed state.

"So far, your tillage has provided a supply of more or less pulverized earth nine or ten inches in depth, on both sides of every interval, and within a few inches' reach of the wheat rootlets. And if you comprehend Jethro Tull's teaching, you will understand that soil more or less pulverized by atmospheric action must be necessarily more or less "fertilized;" hence, your growing plants will have close at hand a deep store of nutriment, on which to feed during the summer. The difference, you perceive, between our method and ordinary subsoiling, lies in the circumstance that every one of the subsoiled furrows remains open and exposed, instead of being immediately buried by a succeeding furrow-slice. And it is not a mere deep stirring without inversion as performed by the tines of a subsoiler or cultivator; neither is it a complete inverting of the staple and subsoil, as in double-digging or trench-ploughing, that we practise. But the staple (that is, a 4-inch stratum of it) is inverted, and *removed by the plough off the subsoil that lies beneath;* and the subsoil is then torn to pieces, and submitted to the disintegration of our changeful English weather.

"As far as you have proceeded at present, half the land is in undisturbed possession of the wheat rows; and the alternate halves, or intervals, are deep-worked on both sides. But as the plough opens a furrow having only 7 or 8 inches of clear bottom, and the subsoiler breaks horizontally only a few inches further toward the centre of the intervals, there will still be a ridge of unmoved ground along the middle of the interval some 10 inches in width. Therefore, in April or May, break up this, and stir the whole breadth of the interval with any suitable subsoiler or grubber. We use Bentall's implement, the central subsoiler, and two side-tines,

without shares; the width altogether being 20 inches, The side wheels are set so as to travel in between the wheat rows, acting at the same time partially as rollers to press in the wheat. The depth worked with three horses on our soil is 5 or 6 inches, which moves the entire breadth of the interval, levelling the high furrow-slice left by the February operation, and mingling and incorporating a considerable portion of the ameliorated subsoil with the upper staple. And in this way, some of the previous surface-mould is replaced by portions of subsoil; and these kept upon the top, and subjected to all the scarifyings and horse-hoeings, the rain, dew, wind, and sun, of a summer and autumnal fallowing, add so much virgin soil to our field, and deepen its productive stratum.

"By way of further direction, we scarcely need insist upon the watchful destruction of weeds that thieve the nourishment provided for the crop, or urge the frequent cutting of the incrusting intervals by the sharpe-knived horse-hoe, to promote the absorption of the atmospheric gifts, and pulverize a rich surface-bed for the spreading wheat-roots to feed in. And of course, the wise husbandman will time this stimulating operation according to the obvious thriving or lagging growth of the plants, and will narrow the width of the implement as the season advances and the roots extend.

"If possible, have the intervals in a state of powder, say by the middle of June; as you should perform another operation when the wheat is in full-ear or going out of bloom, namely, earth-up the wheat rows as you would potatoes, only with care and moderation. This may be done with a ridge or double-mouldboard plough, the horse being driven and guided by a lad walking along the next adjoining interval. Owing to excessive draught, our intervals last summer were

too rough and cloddy to admit of this process being done at all; and as the seed had been imperfectly put in the ground, many odd stalks in the outer-rows were dashed down by the July storms, bent an inch or two above ground, and laid prostrate across the intervals. Gathering up these straws made tedious work for the reapers, and the grain in them was also light. Earthing-up slightly, Mr. Smith finds, will prevent this, without injury or retarding the ripening of the corn. But the stems are stronger than in a common crop, and though liable to twisting and whipping by the winds, are rarely found to lodge.

"You will probably be puzzled about the best way of harvesting: the three-row strips being too narrow for mowing, and if reaped, the stubble when afterwards mown, would be only scattered and dispersed by the scythe. We paid our men extra to reap with hooks or sickles rather close to the ground, and collect the many stalks that lay athwart the intervals; and they had to leave separate "reaps" or handfulls along each stripe to be afterwards gathered into sheaves.

"The subjoined items of expenditure on our 10-acre crop will give an idea of the cost of the operations now described. Manual-labour is charged at the price paid for it; and horse-labour at half-a-crown a day for each horse. The expenses, divided by 10, give *per acre* as follows:—

	s.	d.
Scarifying, cleaning, drilling, &c	16	0
Seed, 3 pecks (at 56s.)	5	3
Bird-keeping	0	4
First ploughing and subsoiling	3	8
Second ditto	3	8
Hand-hoeing wheat	1	10
Scarifying intervals	1	10
Hoe-weeding by hand	3	4

First horse-hoeing intervals	0	9
Second ditto	0	10
Reaping	13	0
Surveying reaper's work	0	3
Carrying, &c	1	11
Thrashing and dressing	8	1
Delivering at market	1	9
Total working expenses	£3	2	6

To which, of course, are added the rent, tithe, rates, taxes, and interest on outlay. And this is the cost of *growing an acre of wheat, and at the same time fallowing that acre for next year's crop.*

" It now remains for us, in concluding this series of papers, to urge the experiment upon all who are desirous of growing wheat at a profit, in spite of low prices. And should our second harvest corroborate the assurance of the first, we shall be able to enforce the adoption of the system on the largest scale."

APPENDIX No. II.

EXTRACTS FROM THE REPORT OF A DISCUSSION IN THE CENTRAL FARMERS' CLUB, LONDON, ON THE QUESTION—*What system of Cultivation upon mixed soils will, under present circumstances, be found most profitable?*

"Mr. Thomas, of Bletsoe, presided, supported by Messrs. Owen Wallis, H. Trethewy, J. Pain, James Wood, W. Fisher Hobbs, S. Skelton, L. A. Coussmaker, T. Congreve, J. Gray, R. Marsh, G. Smythies, J. Cressingham, J. Wood (Croydon), C. J. Brickwell, W. Heard, J. Beddoe, J. Hooker, J. S. King, F. J. Baines, J. Parkinson, J. C. Morton, T. Lyall, J. Maund, D. Reid, H. Gibbons, P. F. Pell, &c.

"In the absence of Mr. Baker, of Writtle, from illness, the subject was introduced by Mr. Owen Wallis, of Overstone Grange, Northampton.

"Mr. Wallis, after expressing his regret at the cause of Mr. Baker's absence, and claiming the indulgence of the meeting for himself, as having unexpectedly been called upon to take up a question which was assigned to another member, proceeded as follows:—The subject for discussion as proposed by Mr. Baker, is—"*What system of cultivation upon mixed soils will, under present circumstances, be found most profitable?*" This is by no means an easy question to answer; it is not easy to give an answer to it that will not be open to dispute. There can be no means of proving the superiority of one system over another, until they have

been tried one against the other, under the same circumstances and conditions, for a number of years, and accurate accounts of the profit and loss of each faithfully recorded. This, however, has never been done, that I am aware of; and even if it had, other circumstances would have to be taken into account which might render the trial anything but conclusive. For instance, one system, though at first the most profitable, might contain within itself the seeds of its own destruction by exhausting the soil of certain properties essential to the production of healthy crops; while the other, by the non-exhaustion of those properties, might be continued for an indefinite period. The question, then, becomes one of opinion only, and not of positive proof. We may, however, from the information which our daily observations afford us, form pretty correct conclusions; and I think it is now very generally agreed, that on light soils the four-course system can no longer be defended, but that a more extended rotation must be adopted, in order that the turnip and seed crops may be sown less frequently, and by that means, it is hoped, grown more successfully. That this opinion is rapidly gaining ground, is shewn by previous discussions at this Club. It is also apparent from the proceedings of the Royal Agricultural Society of England; for in the schedule of prizes last issued is one of Twenty Sovereigns 'for the best report on the modifications of the four-course rotation which modern improvements have rendered advisable.' There is also another prize of Twenty Sovereigns, 'for the best report on the causes of the increasing difficulties of turnip cultivation, and the remedies.' Every year, indeed, brings additional evidence of the necessity of a change; for, notwithstanding the assist-

ance we have derived of late years by the use of artificial manures, the turnip crop is becoming rapidly more precarious, and is deteriorating both as to weight and quality. The difficulty as to the clover plant has long been felt; but, great as the loss from its failure has been, we have found less difficulty, on the generality of farms, in keeping our stock in summer without clover, than in winter without turnips. Now, however, that the double difficulty has come upon us, we have no alternative but to look about for a remedy. But there is not only this difficulty as to the green crops; there is an equal deficiency in the barley. On most of the farms with which I am acquainted that crop has fallen off nearly one-third in quantity, and the quality is inferior in comparison with former years. Six quarters per acre used to be obtained where four can only be got now, and this, too, with the land in a much higher state of cultivation than formerly. It used to be strong and reedy in the straw, and stand up till ripe; but now, it is no sooner a few inches high than it tumbles about in all directions; and, though in appearance a great crop, there is in reality nothing but a lot of soft weak straw and about two-thirds of a crop of inferior corn. Its effects upon the young clover seeds are very injurious. Those that live are very much weakened, and a great part of the plant is often lost altogether. It being, therefore, apparent that a more extended rotation of cropping must be adopted, we have to inquire what other is likely to prove the best substitute for the four-course one. On ordinary soils, the extension of the white corn crops should, I think, depend upon the amount of artificial food, or purchased manures, used upon the farm, unless they are accompanied by a corresponding

increase in the green crops. There can be neither reason nor justice in restricting one tenant, who uses these very liberally, to the same covenants as to cropping as you do another who either uses them sparingly, or not at all. A departure from one general rule may give some trouble to agents on large estates; but cases ought nevertheless to be dealt with on their own merits, and the good and the bad tenants no longer tied down by the same restrictions. * * *

"Mr. J. Pain (Felmersham, Bedford) said he quite agreed with Mr. Wallis, that the system of growing turnips once in four years, on light land, was not a good one. If not yet abandoned, he believed it soon would be, as the cultivation came round too frequently for the turnips and for the clovers. On his own farm he had carried out a different system for the last three or four years. He could hardly get any turnips at all; and, therefore, he adopted a six-course shift, which he believed afforded a little better chance. What they called turnip land was quite sick of turnips; and the best remedy was, in many cases, to sow mangold instead of turnips.

"Mr. L. A. Coussmaker (Farnham) could corroborate what Mr. Pain had said in reference to the general failure of the turnip crop." "He found that he could not grow tares as he used to do. In the course of his twenty years' farming, his farm had, he considered, been very much improved. He had manured it strongly; still he could not grow green crops, roots, or tares as he did formerly. Mangold wurzel was an exception; that did not deteriorate: if he put on plenty of dressing, he never found it to fail. * *

Mr. Smithies (Marlow, Leintwardine) said, "he felt personally very much obliged to Mr. Wallis for his able

introduction, and he hoped it would induce landlords to allow good tenants to farm more in accordance with their own notions, instead of the notions of some lawyer in a small town, or rather, of his great grandfather. (Laughter.) The time had certainly come when those who farmed high could not farm on the four-course system. He had himself been obliged to depart from that system on account of his barley having gone down, a loss of that kind being, in a stock country like his, a very serious matter indeed."

"Mr. Fisher Hobbs, (Boxsted, Essex) thought they were pretty well agreed that the usual mode of cultivating mixed soils, namely, the four-course system, was not the most profitable. He could not lay down any particular mode of cultivation for his own farms, because they consisted of very different soils, and had been remodelled rather with a view to letting than to the adoption of any particular system. It was evident, however, that the four-course system ought now to be considered out of date for mixed soil land; and he thought all wise landlords must be disposed to give increased facilities for cultivation when they saw intelligence and capital combined in their tenants, so as to enable the occupier to grow what the land was really capable of growing."—"He had no doubt that the use of salt was in many cases very advantageous; but he thought wide drilling had quite as much to do with the stiffening of straw as the application of salt. When wheat was drilled 10 or 12 inches wide, he had found the straw much heavier and standing much better than when a different mode of cultivation was pursued. He thought the application of salt, mixed with guano, tended very much to stiffen the straw.

"Mr. P. F. Pell (Scopwick, Sleaford, Lincolnshire) said,

for the last three or four years there had been great complaints in the part of the country with which he was connected of the failure of the turnip crop ; and he knew that the great bulk of the farmers in the wolds and heaths said that the turnip was much more liable to decay than it used to be.

" Mr. O. Wallis, in replying, said, he could not admit that the failure of the turnip crop was attributable to the use of artificial manures. Some of the worst tubers he had ever seen were on land where no artificial manure at all had been used. He believed the falling-off was owing to the abstraction of some important element from the soil by the too frequent growth of turnips ; and, far from thinking that artificial manures had contributed to it, he was of opinion that the introduction of them had tended very much to keep the turnip afloat. His remarks with regard to straw applied not to wheat, but to barley, Every one was complaining of the failure of the barley crop, both in quantity and quality.

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APPENDIX III.

TABLE SHEWING THE COMPARATIVE RENT OF LAND, AND THE ACREABLE PRODUCE OF WHEAT IN 1770 AND 1850–1.

The following particulars are taken from tables at pp. 474 and 480 of *Caird's English Farming.*

	1770. On Arthur Young's Authority.		1850–1. On Caird's own Authority.	
	Rent.	Prod. in *B.*	Rent.	Prod. in *B.*
	£ s. d.		£ s. d.	
Average acreable rent and produce of wheat, in fifteen of the inland and Western counties of England (the mixed grass and corn districts)	0 14 6	24½	1 11 5	27
Ditto of eighteen East and South-west counties, being the chief corn producing districts	0 12 8	21½	1 3 8	26½
Average....	0 13 7½	23	1 7 6	26¾

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ERRATA.

Page 88, line 15th ; *for* "17th century," *read* 18th century.
" 110, " 5th ; *for* "flattened ridge," *read* narrowed ridgelet.
" 198, " 5th, foot note ; *omit* "occasioned."
" i. " 3rd, Appendix ; *for* "Journal," *read* Magazine.

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